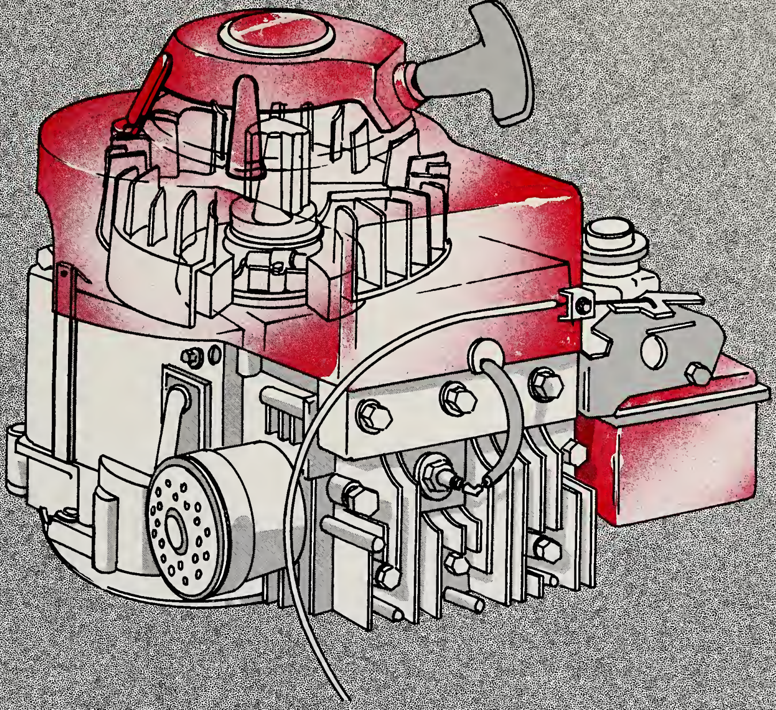

SMALL GASOLINE ENGINES

THEORY OF OPERATION AND MAINTENANCE

ALBERTA DISTANCE LEARNING CENTRE

Small Gasoline Engines

THEORY OF OPERATION AND MAINTENANCE

Distance Learning

Alberta EDUCATION

Small Gasoline Engines
Student Module
Lessons 1-4
Alberta Distance Learning Centre
ISBN No. 0-7741-0791-X

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OBJECTIVES

Small Engine Tune-up and Troubleshooting is an introductory course relating to small gasoline engines. The emphasis is placed on engines of the air cooled variety. The main purpose of this course is to provide the student with a logical system for analyzing and tuning a small gasoline engine.

There is no textbook for this Small Engine course. All information is contained in the lessons themselves. General references relating to small engines would be helpful to students who want to advance their skill and knowledge beyond the scope of this course. Some references are listed later in the Introduction. A shop manual for the specific make and model of small engine you have is a necessary asset for working on that small engine.

Non-liability of the School

While every care has been taken in the preparation of practical work instructions, we cannot be responsible for damage to an engine or injury which results from work you may perform on your engine. If you are going to do practical work you must be willing to accept responsibility for your own actions in this regard.

General Instructions

(a) When you receive this course, take it apart carefully so that the pages will remain untorn. If you open the book firmly in the middle, the staples will separate and the book will come apart. You can then remove the whole pages without tearing them. Use rings or a looseleaf binder to keep the pages together.

(b) Send in for correction **only** those pages which require marking. **Do not** send in the entire lesson as this just costs you unnecessary money for postage.

(c) Try to form good habits of study. After you have read the assigned pages, read through the exercises. See how well you can answer them. If you have difficulty with any of the exercises, you may find it necessary to read the entire lesson material a second time.

(d) Before you start an exercise, be sure that you read the instructions thoroughly so that you understand them.

(e) When a lesson is returned to you, study the corrections and comments made by the teacher. Find out what parts of your work have been good, and what parts could be improved. Try to benefit from the corrections. Similar mistakes in successive lessons indicate that the student is not giving sufficient attention to the corrections.

(f) Avoid using abbreviations, ditto marks, and the symbol "&" for the conjunction "and" in your written answers. All words should be written in full.

(g) Before sending a lesson for correction, check to be sure that all exercises are completed.

(h) Please use dark ink for all written exercises. Do not write with pencil or red ink. Avoid writing with pencil first and then going over the work with ink.

(i) Blank paper tells your instruction nothing and will not be accepted. If for some reason you can not answer a specific question, then detail for your instructor why you can not answer it and the instructor will try to help you, if your reasons are sensible and acceptable.

(j) Before mailing your lessons, please see that:

(i) All pages are numbered and in order, and no paper clips or staples are used.

(ii) All exercises are completed. If not, explain why.

(iii) Your work has been re-read to ensure accuracy in spelling and lesson details.

(iv) The Lesson Record Form is filled out as required and the adhesive address label is placed in the space provided.

(v) This mailing sheet is placed on the lesson.

(k) Do not enclose letters with lessons. Send all letters in a separate envelope.

(l) Take your lesson to the Post Office and have it weighed (or refer to the schedule of postal rates which will be enclosed with your corrected lessons). Attach sufficient postage and a green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used. Lessons can be sent in by third class mail, however they will take longer to reach the Alberta Correspondence School.

You should try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly but to avoid sending more than two or three lessons in one subject at the same time.

Metrication

The course is written using SI units exclusively. The table of prefixes shown below is a reference guide so you can easily understand what metric prefixes mean.

Prefix	Symbol	Meaning	Multiplier
*kilo	k	one thousand	1 000 $= 10^3$
hecto	h	one hundred	100 $= 10^2$
deca	da	ten	10 $= 10^1$
*		one	1 $= 10^0$
deci	d	one tenth of a	0.1 $= 10^{-1}$
*centi	c	one hundredth of a	0.01 $= 10^{-2}$
*milli	m	one thousandth of a	0.001 $= 10^{-1}$
*Most commonly used.			

Below is an example of the unit of length (metre) and the prefixes commonly used with it.

Unit	**Symbol**	**Meaning**	**Example**
kilometre	km	10^3m	Length of brisk 10 min walk.
metre	m	1 m	Height of 3-drawer filing cabinet.
millimetre	mm	10^{-3}m	Thickness of a dime.

The table below is put in the order of most probable frequency of use. Units that would be used frequently are put first, and units less frequently towards the last.

QUANTITY	NAME	SYMBOL	NOTES
length	millimetre centimetre metre kilometre	mm cm m km	 A Volkswagen is about 4 m long.
area	square centimetre square metre	cm^2 m^2	
volume	cubic centimetre cubic metre millilitre litre	cm^3 m^3 mL L	1 cm by 1 cm by 1 cm There are 1 000 mL in 1 L. 1 L is the volume of a cube 10 cm by 10 cm by 10 cm.
mass	gram kilogram milligram tonne	g kg mg t	 1 t is 1 000 kg, this is about the mass of a Volkswagen.
temperature	degree Celsius	°C	A comfortable room has a temperature of 20°C.
time	hour minute second	h min s	
speed	kilometre per hour metres per second metres per hour	km/h m/s m/h	A good highway cruising speed would be 100 km/h
acceleration	metres per second squared	m/s^2	
gas consumption	litres per one hundred kilo-metres	L/100 km	We are to express gas consumption by cars in litres per hundred kilometres, that is, the amount of gasoline it takes for the car to travel 100 km. For instance, a large car may consume gas at 20 L/100 km, while a smaller car may only require about 8 L/100 km. The lower the number of litres, the less gas you consume. This way of stating fuel consumption is prevalent in Europe and other metric areas of the world.
pressure	pascal kilopascal	Pa kPa	 The atmospheric pressure is about 100 kPa.
power	watt kilowatt	W kW	 A lawnmower motor has a power of about 2 kW.

QUANTITY	NAME	SYMBOL	NOTES
force	newton	N	The newton is roughly the force required by your hand when supporting 2 golf balls.
electric current	ampere	A	
electric potential, potential difference, electromotive force	volt	V	
resistance	ohm	Ω	
rotational frequency	revolutions per minute	min^{-1}	An LP record has a rotational frequency of 33 min^{-1}.
energy, work	joule	J	
moment of force, torque	newton metre	N·m	
density	kilograms per cubic metre	kg/m^3	
relative density	The terms "specific weight" and "specific gravity" should be replaced by the term "relative density". Mercury has a relative density of 13.6, meaning that it is 13.6 times as dense as water. Water is implied as the reference substance for liquids and solids, and air the reference for gases, unless indicated otherwise.		
capicitance	microfarad farad	μF F	
electric charge	coulomb	C	One coulomb is the charge transported in 1 s by a current of 1 A.
electric flux	coulomb	C	
magnetic field strength	ampere per metre	A/m	

Below is a list of rules for writing SI Metric Units.

(a) The symbols are always printed in Roman (upright) type, irrespective of the type of face used in the rest of the text.

(b) Symbols are never pluralized: 45 g (not 45 gs).

(c) Never use a period after a symbol, except when the symbol occurs at the end of a sentence. This is done because SI symbols are **symbols** they are **not** abbreviations.

Example: the symbol for kilogram is kg **not** kg.

(d) Symbols should usually be used and unit names not mixed with symbols.

Example: 10 kg (preferred), ten kilograms (accepted), never 10 kilograms.

(e) Always use a full space between the quantity and the symbol: 45 g (not 45g)

Exception: For Celsius temperatures the degree sign occupies the space. 32°C (not 32° C or 32 °C)

(f) Use decimals, not fractions: 0.25 g (not 1/4 g) (the decimal is a point on the line in English).

(g) A zero is always used before a decimal marker: 0.45 g (not .45 g)

(h) Symbols are written in lower case, except when the unit is derived from a proper name:

m for metre, s for second; but N for newton; A for ampere; degree Celsius °C is the only one to be upper case in both name and symbol.

(i) Prefixes are printed in Roman (upright) type without spacing between the prefix and the unit symbol: kg for kilogram, km for kilometre

Only one prefix is applied at one time to a given unit: megagram
or tonne
not kilokilogram

(j) Use spaces to separate long lines of digits into easily readable blocks of three digits with respect to the decimal marker: 32 453.246 072 5

Exception: A space is optional with a four-digit number: 1 234 or 1234

(k) Multiplication of Units in symbolic form is indicated by a dot at mid-letter height between the symbols.

(j) Division of Units in symbolic form is indicated by an oblique stroke between the symbols, or by a negative symbol.

References

Crouse W.H., *Small Engines: Operation and Maintenance* McGraw-Hill Ryerson.

Briggs & Stratton, *Four Stoke Cycle,* flip chart, # MS 4602-24, Briggs & Stratton Corp.

Briggs & Stratton, *General Theories of Operation,* form # MS 3553-24, Briggs & Stratton Corp.

Briggs & Stratton, *Repair Instructions,* form # 4750-101, Briggs & Stratton Corp.

Chilton, *Repair & Tune-up Guide for Small Engines,* Chilton Book Co., 81 Curlew Drive, Don Mills, Ont., M3A 2R1

Intertec, *Small Engines Service Manual,* any ed., Intertec Publishing Corp., 1014 Wyandotte Street, Kansas City, Missouri, U.S.A. 64101.

Tecumseh, *Mechanics Manual,* part number 692147, Tucemseh Products Co., Grafton, Wisconsin, U.S.A. 53024, available from Lambert Electric Ltd., 114 Avenue A North, Saskatoon, Sask. S7L 6Y7.

Roth, A.C., *Small Gas Engines,* The Good Heart - Willcox Company, Inc, South Holland, Illinois, U.S.A. 1978.

Owners Manuals for specific make and model.

Shop Manuals for specific make and model.

These references are **not** required to complete this course, but could be of value to you if you wish more information than is given in the following lessons, or if you do wish to do actual engine repairs.

LESSON RECORD FORM

5037 Small Engines

Revised 91/09

FOR STUDENT USE ONLY	
Date Lesson Submitted ______________	(If label is missing or incorrect) File Number ______________
Time Spent on Lesson ______________	Lesson Number ______________

Student's Questions and Comments

Apply Lesson Label Here

Name ______________

Address ______________

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Postal Code ______________

Please verify that preprinted label is for correct course and lesson.

FOR A.D.L.C. USE ONLY

Assigned Teacher: ______________

Lesson Grading: ______________

Additional Grading E/R/P Code: ______________

Mark: ______________

Graded by: ______________

Assignment Code: ______________

Date Lesson Received: ______________

Lesson Recorded ______________

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 14-91

ALBERTA DISTANCE LEARNING CENTRE

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do **not** enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.

Try to **mail each** lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

St. Serv. 9-91

USE OF TOOLS AND EQUIPMENT

INTRODUCTION

This lesson identifies the more common tools used in the servicing of small engines. Most **of the tools required are basic hand tools, however, some specific tools may be necessary to make your work more effective and faster.**

When purchasing tools, consider their use:

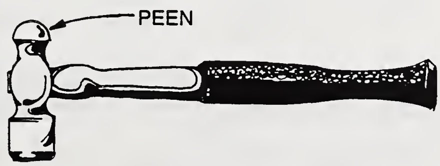
(1) Will they be used daily?
(2) Will they be used on an occasional basis?
(3) Are the tools subject to abuse?
(4) Is accuracy required in the job to be done?

Their use along with how much you can afford to spend will determine what kind of tools to purchase. It is advisable to shop around whether you are purchasing tools new or second hand.

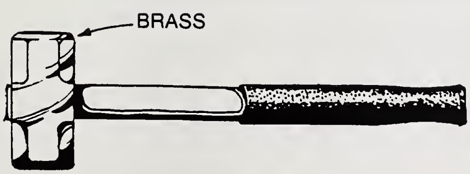
HAND TOOLS

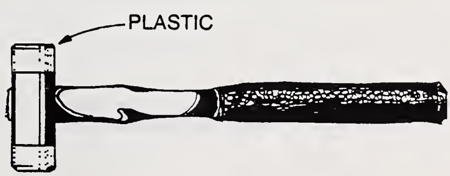
1. Hammers

(a) Ball peen - this type of hammer is used for general striking, riveting, and gasket cutting.



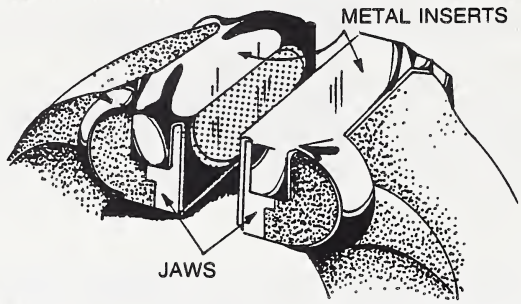
(b) Plastic faced or lead and brass - this type of hammer is used to prevent marring of surfaces that may be hit.





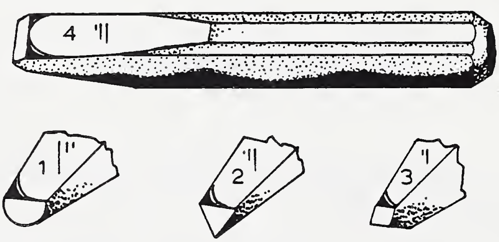
2. **Vise**

The vise is very useful for holding parts while you are working on them. To protect the work from being damaged by the jaws of the vise, soft metal inserts should be placed for the jaws.



3. **Chisels**

Chisels are used for cutting off rivet heads, rusted nuts, and bolts.



Type of Chisels. 1-Half round. 2-Diamond. 3-Cape. 4-Flat

4. **Punches**

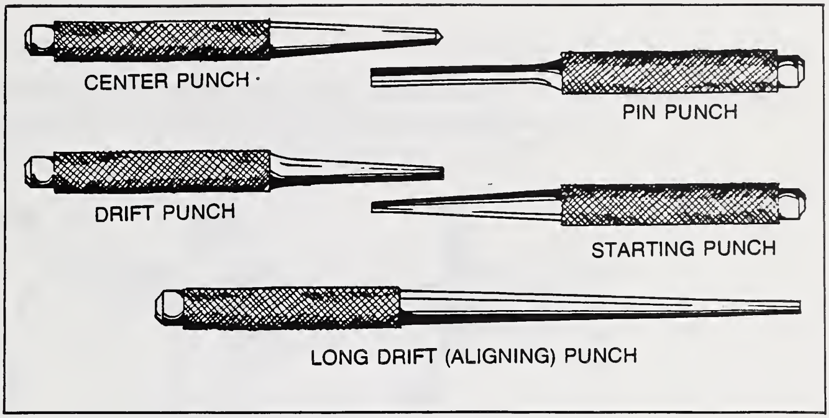
(a) Starting punch - used to start driving rivets and bolts from a hole.

(b) Drift punch - finish the job listed above.

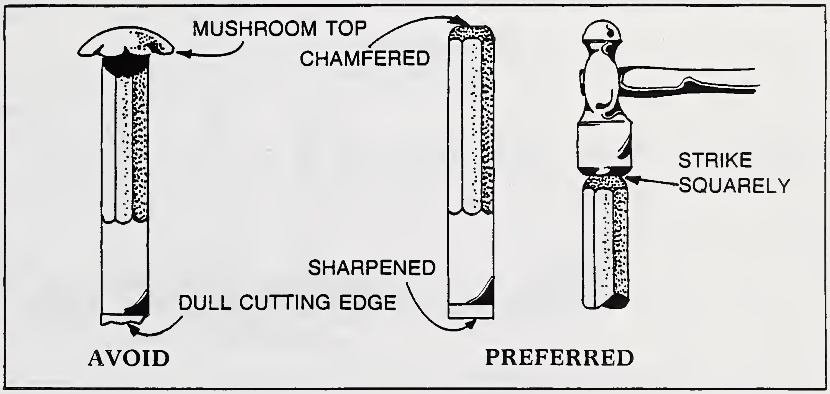
(c) Pin punch - useful in removing small bolts and pins.

(d) Center punch - marks the center of a hole before drilling. Also used for marking parts so they can be assembled in their original position.

(e) Aligning punch - used for shifting two or more parts so their holes will line up.

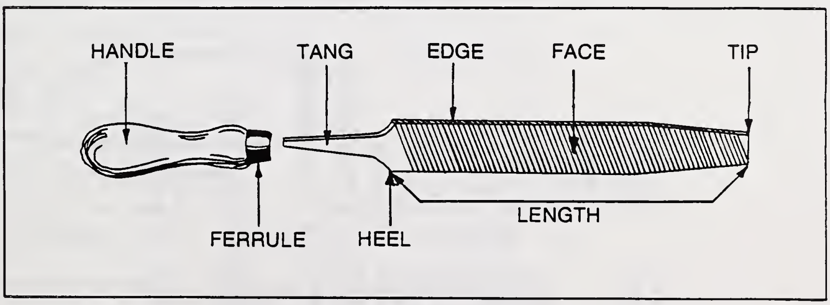


SAFETY NOTE:

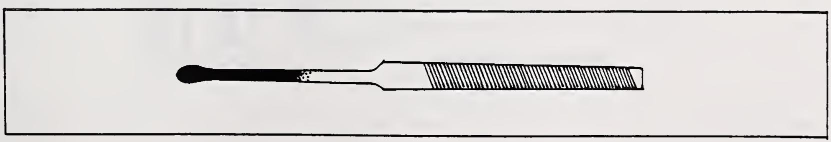


5. **Files**

Files are used to smooth rough edges or burrs. Various shapes and sizes of files are available. All files should have securely attached handles.

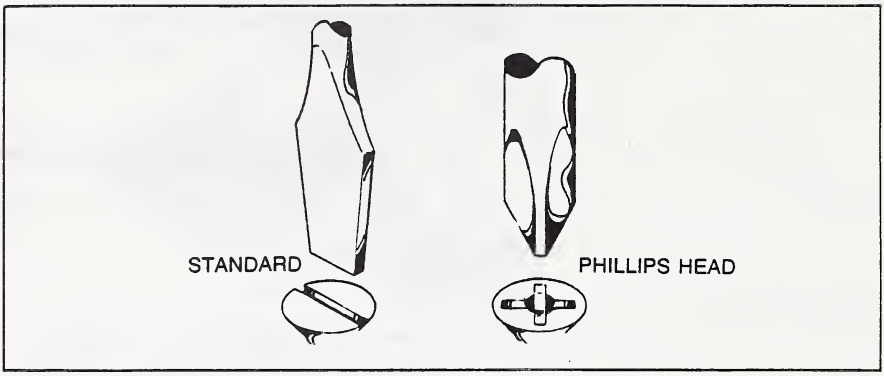


Ignition-point files are used to touch up any roughness or pits that exist on ignition points.

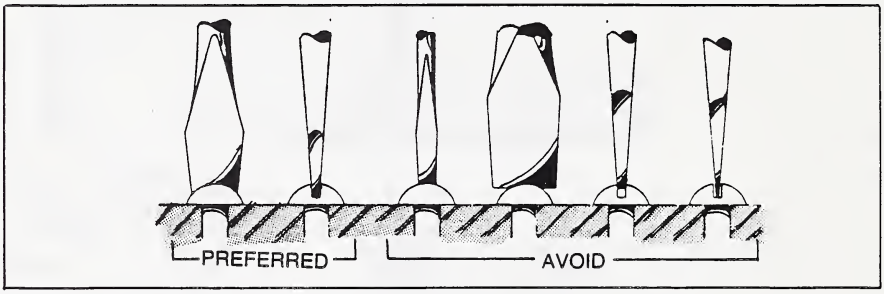


6. **Screwdrivers**

Two or three sizes of slot or standard screwdrivers will be necessary for general small engine work. Phillips screwdrivers will be necessary for removing shields, shrouds, etc. from most small engines.



Use the correct size of screwdriver for the job to be done.



7. **Pliers**

There are several styles of pliers available. Pliers are used for cutting wire, holding parts, crimping electrical connections, bending cotter pins, etc. Never use pliers to turn nuts, bolts, tube fittings, or to cut hardened objects. The beginner should use a combination of slip-joint pliers.

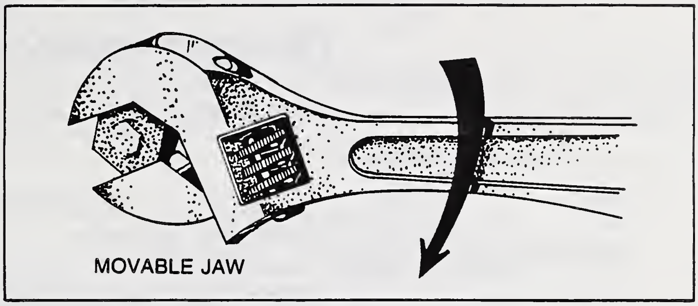
COMBINATION SLIP-JOINT PLIERS

8. **Wrenches**

Many types of wrenches are available to the small engine mechanic. Each type is designed for a particular use.

(a) Adjustable Wrench

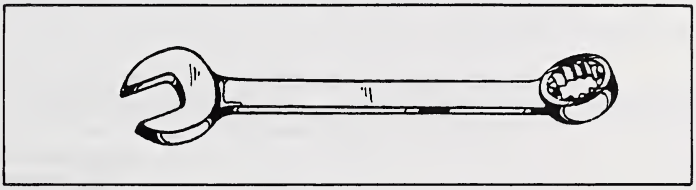
This type of wrench adjusts itself to a wide range of sizes. Choose the smallest adjustable wrench that will fit the fastener being worked on.



NOTE: The movable jaw of the wrench should always face the direction the fastener is being turned.

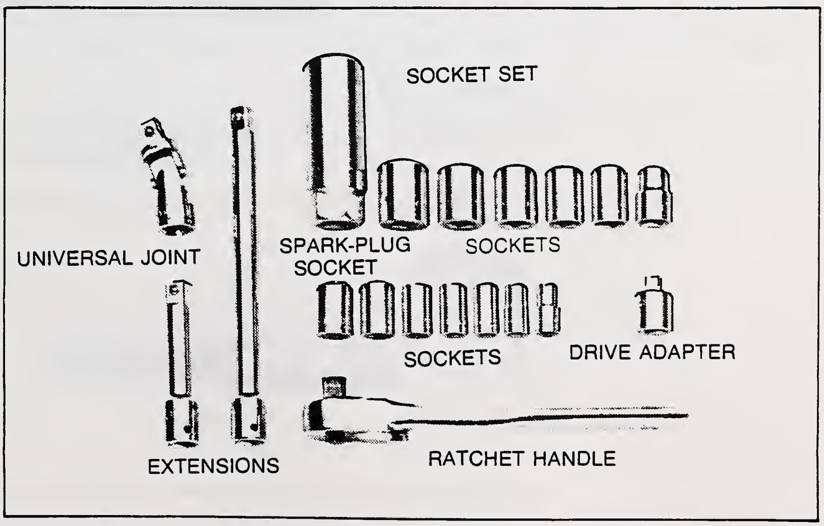
(b) Combination Wrenches

These tools come in sets of varying sizes. Obtain a wrench set which has wrenches large enough to meet your needs.



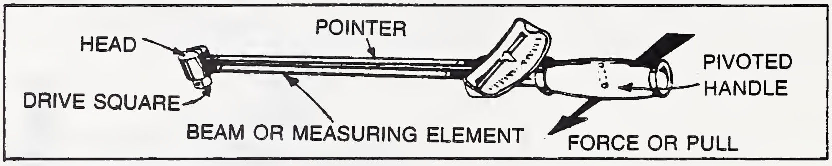
(c) Socket Sets

Socket sets contain several sockets, a ratchet, an extension and possible other parts. Sockets are used for general maintenance such as removing nuts from bolts. It is best to obtain a set large enough to meet your needs.



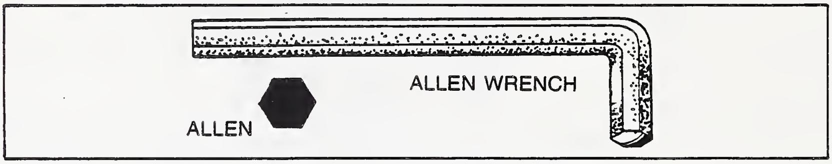
(d) Torque Wrenches

Torque wrenches are used to prevent undue stresses and strains on parts causes from overtightening fasteners.



(e) Allen Wrenches

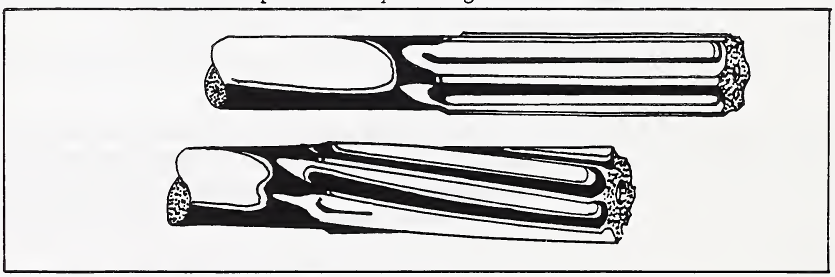
Allen wrenches are used to turn set screws and cap screws. These wrenches are available in various sizes and lengths.



SAFETY NOTE: Never push on a wrench. This may cause bruised knuckles if the fastener happens to break loose suddenly.

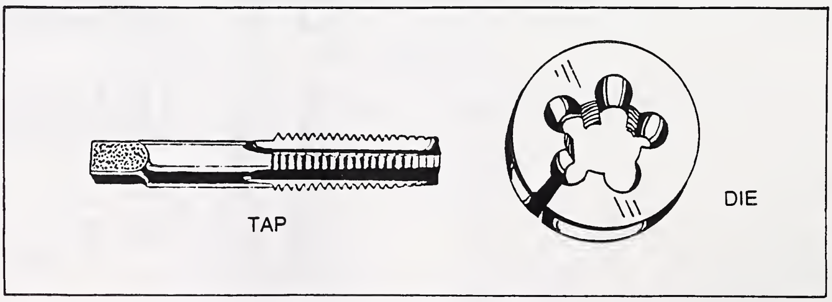
9. Reamers

This tool is used to enlarge, shape, or smooth holes. The result is much smoother and more accurate than that produced by drilling.



10. Taps and Dies

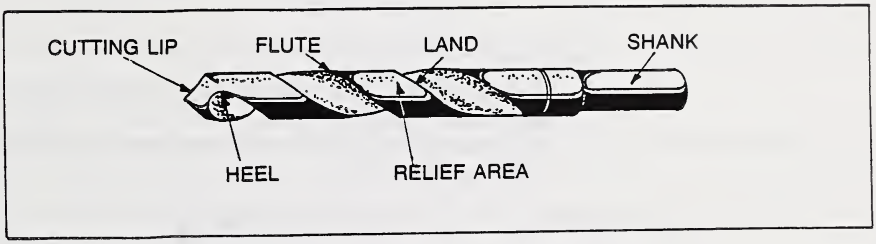
Threads can be cut by hand with a tap and die. Taps are used to cut internal threads like those cut in a nut. A die is used to cut external threads on a rod such as those on a bolt.



There are two common thread sizes. The National Fine is often used for precision assemblies and the National Coarse is used for general purpose work.

11. Drills

The uses for twist drills are too numerous to list. Various fractional size drill sets are available as well as metric sets. Better quality drills are made of high-speed steel and can be readily sharpened without losing their temper (strength).



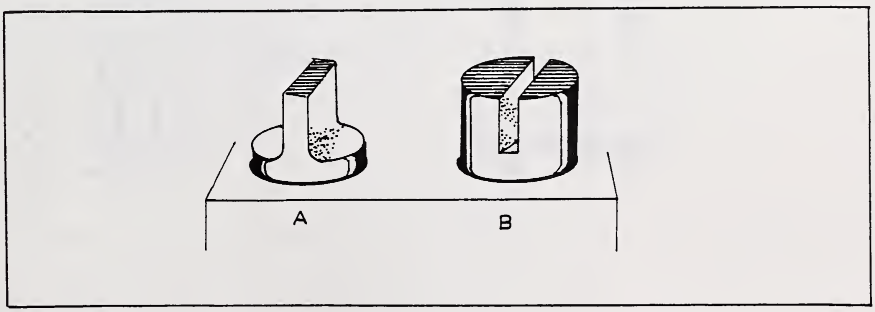
Suggestions before drilling a hole include:

(a) Center punch the spot to be drilled. This prevents the drill bit from wandering sideways.
(b) Cutting oil is not necessary when drilling cast iron, pot metal, and aluminum but should be used when cutting hardened steel.
(c) Apply only enough pressure to produce good cutting.
(d) To prevent the twist drills from grabbing the material ease up on the feed pressure just before the drill breaks through the material.
(e) Secure the piece to be drilled solidly.

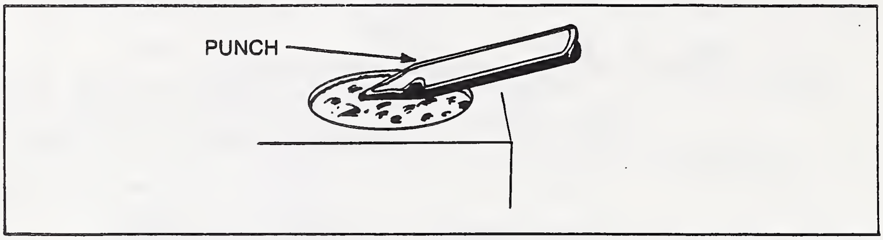
12. Stud and Bolt Removers

Several methods may be used to remove a broken stud or screw.

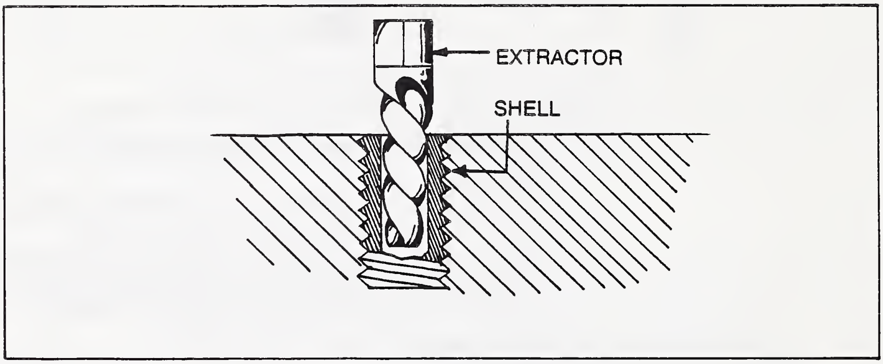
(a) If some portion of the stud or stripped head of a screw projects above the work piece, it may be gripped with a stud remover wrench or visegrip pliers and backed out.
(b) When the portion protruding is not sufficient to grasp it may be filed to take a wrench (A below) or a slot may be cut (using a hacksaw) to allow a screwdriver to be used (B below).



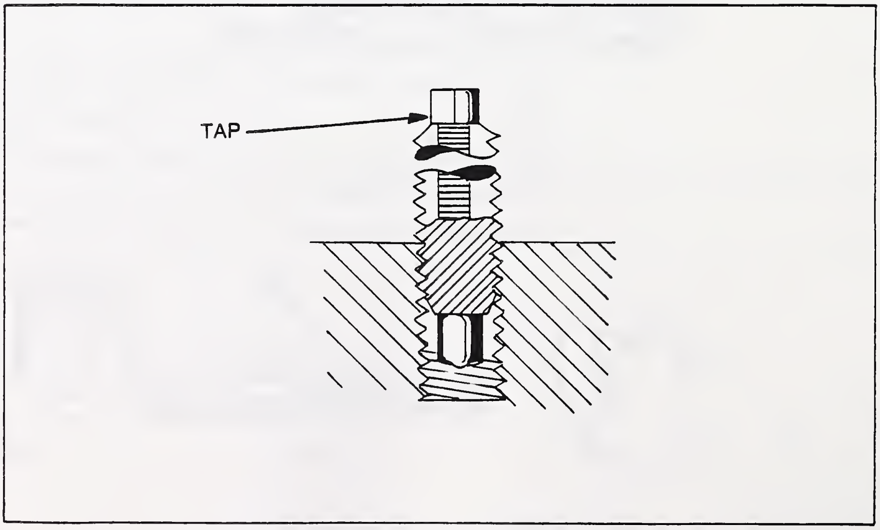
(c) If the head or stud is broken off flush or slightly below the surface try driving the broken section in a counterclockwise direction with a thin, sharp, pointed punch.



A screw extractor is a tool that can be used with good results. Locate and mark the centre of the stub using a center punch. Using a small diameter drill cut a hole through the stub. Tap the extractor into the hole with a hammer and back it out using a wrench.

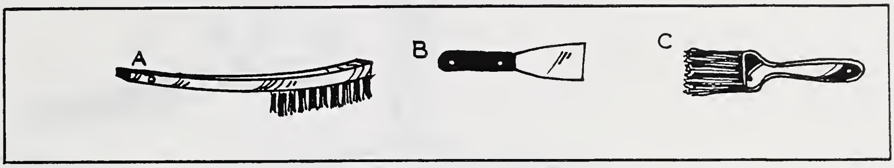


(d) If the previously mentioned methods fail, run the proper tap size drill through the stub shell. Then carefully tap out the hole. The tap should remove the remaining shell threads.



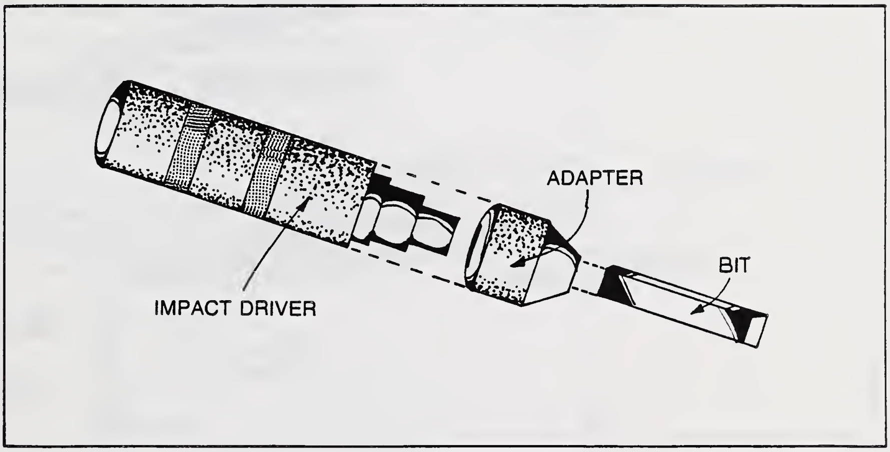
13. **Cleaning Tools**

A number of cleaning tools are available. The most useful for our purpose include: a wire brush (A), a flexible scraper (B), and soft bristle cleaning brush with nylon bristles (C).



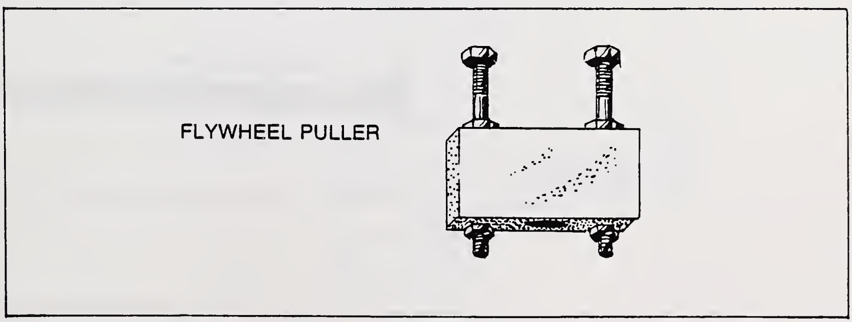
14. **Impact Driver**

An impact driver frees stuck bolts and with an adapter for a screwdriver head, it can also loosen frozen screws.

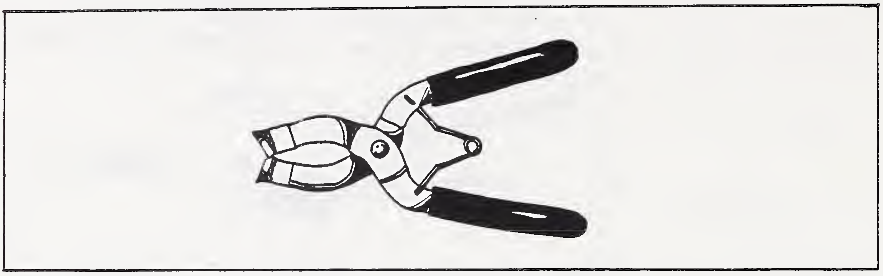


SPECIALIZED TOOLS

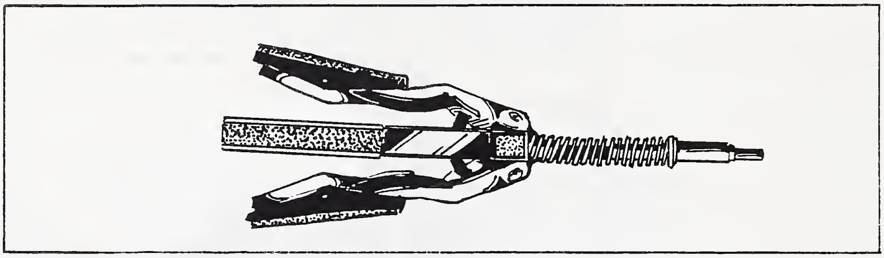
1. **Flywheel Puller** - If prying and gentle tapping will not pry the flywheel loose, a specifically designed puller will be necessary in order to free the flywheel.



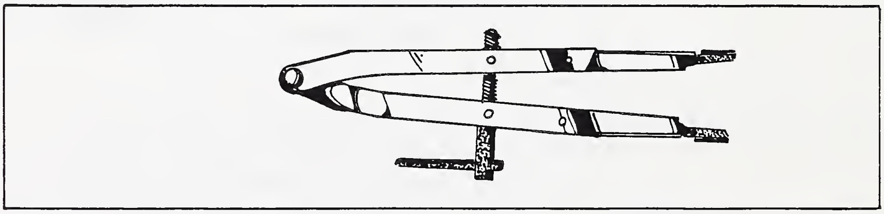
2. **Piston-ring Expander** — This tool gently expands piston rings so they can be installed or removed without breaking.



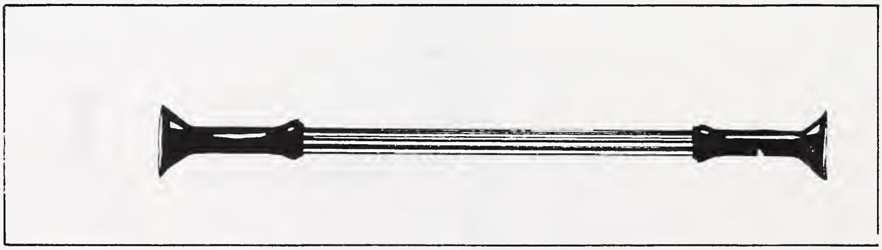
3. **Cylinder Hone** — The cylinders of some small engines may require deglazing. Deglazing the cylinder is accomplished using a cylinder hone in conjunction with a portable electric drill.



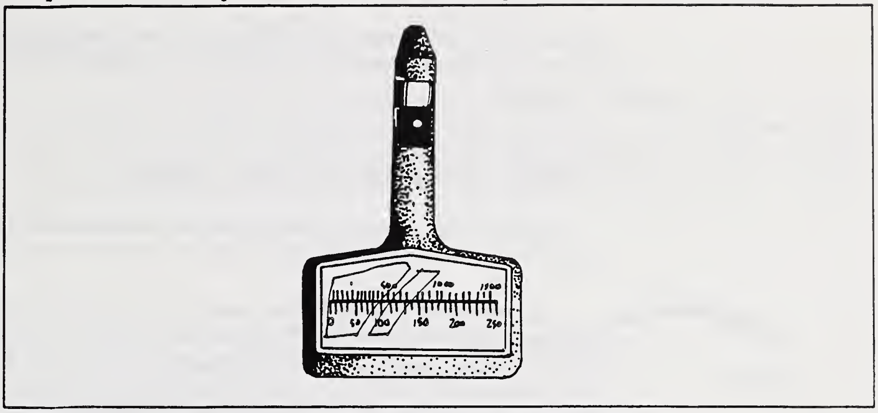
4. **Valve-Spring Compressor** — In order to facilitate the removal of valve springs a compression tool known as a valve-spring compressor is used.



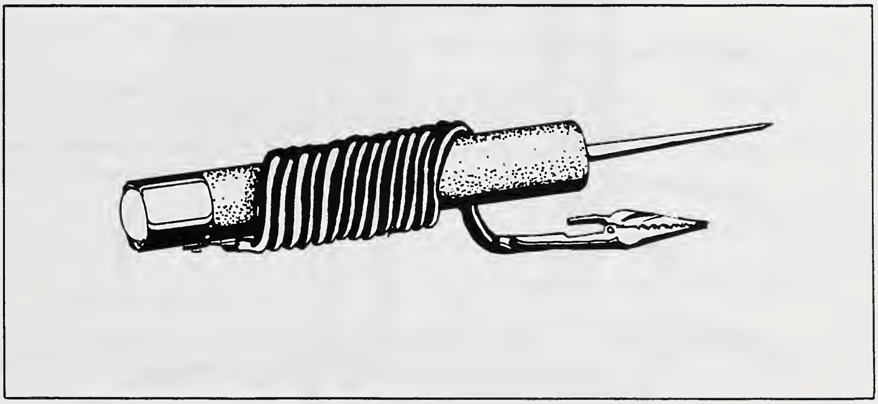
5. **Valve-lapping Tool** — This tool is used to polish the valve seal in order for the valve to seal properly.



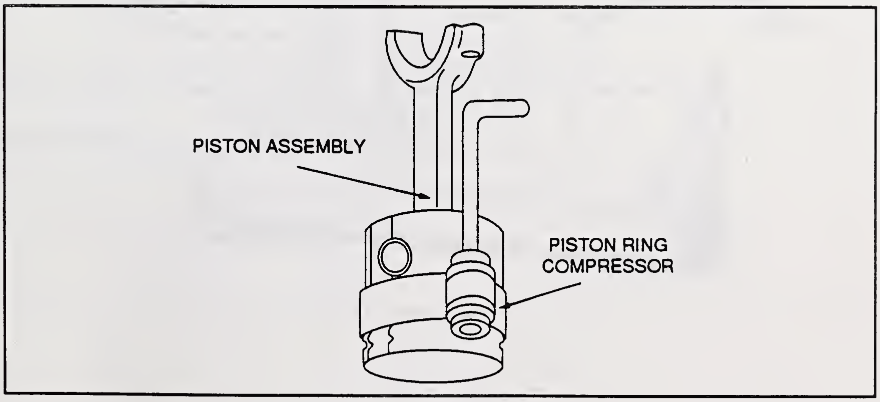
6. **Compression Tester** — A compression tester is used either to determine the compression in the cylinder or to aid in the diagnosing of compression problems.



7. **Continuity Tester** — This tool is used to check ignition timing.



8. **Piston Ring Compressor** – This tool is used to compress the piston rings before inserting the piston assembly into the cylinder.



PARTS CLEANING EQUIPMENT

Various methods for cleaning small engine parts are available. Expensive equipment is not necessary. A few handtools, some rags, a pail and some type of cleaning solvent is all that is required.

1. Cleaning With a Wire Brush and Scraper

External parts require cleaning before the disassembly process can begin. Brushing away the accumulated dirt and grime is all that is usually necessary.

Internal parts such as valves, combustion chambers, piston heads, and gooves, as well as cylinder heads are subject to accumulations of hard carbon. Careful cleaning with scraping tools and a wire brush will remove most of these deposits. Remember that most these parts are made of soft metal (aluminum alloys) and will be easily damaged if great care is not taken while cleaning.

2. Soak-Cleaning

A variety of cleaning solvents and solutions are available for use. Varsol is an inexpensive and relatively safe solvent to use on small engine parts. **Never use gasoline or any low flash point solvent.** The part or parts are placed in a small pail and soaked from ten to thirty minutes. They can be removed and wiped or blown dry with an air gun.

3. Safety

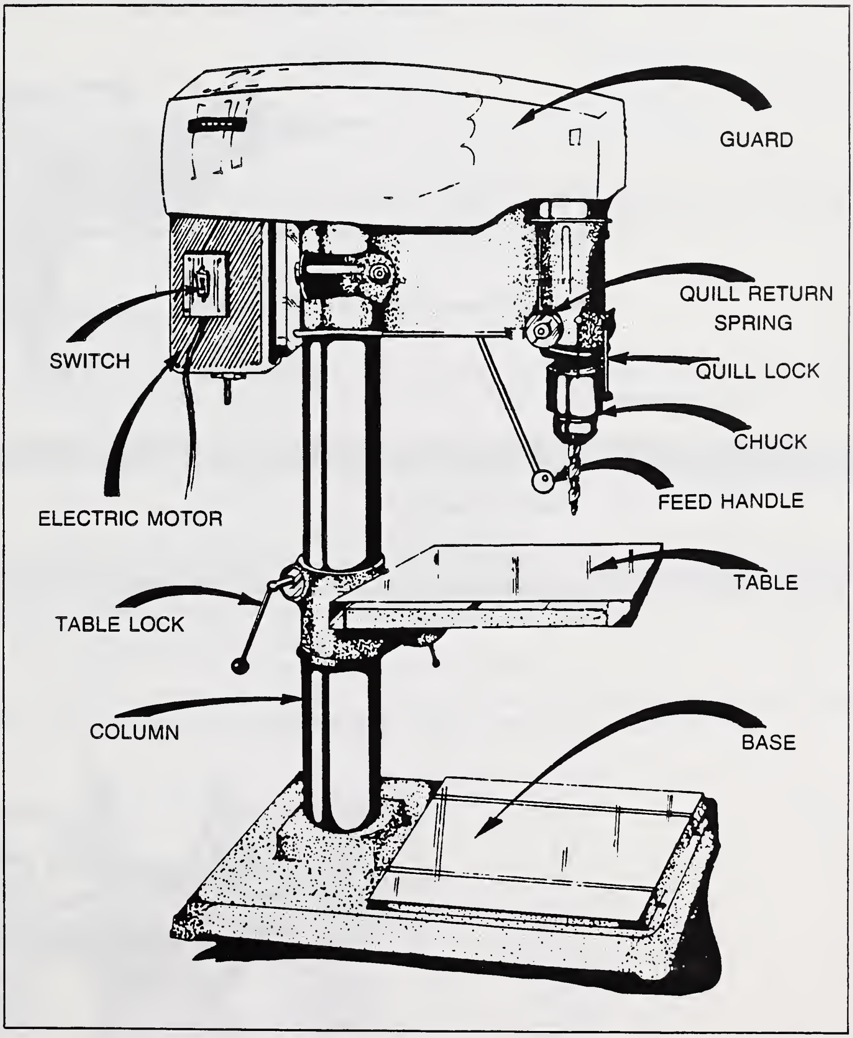
Always follow the manufacturer's recommended handling procedures for all cleaning solutions. Some general safety rules to remember when using solvents are:

(a) Never use gasoline for cleaning.
(b) Use all solutions in a well ventilated area.
(c) Wear goggles or a face shield.
(d) Keep away from sparks or open flames.
(e) Keep solutions covered when not in use.
(f) Store solutions in labeled containers.
(g) Use a nylon or brass bristle brush to avoid any sparks from occurring.
(h) Avoid prolonged skin contact.
(i) Wash hands thoroughly with soap when the cleaning job is complete.

POWER TOOLS

1. Drill Press

This machine is used to cut round holes in material. The major parts include an electric motor, a spindle mounted chuck (for securing the cutting tool), and a feed control. The drill bit is secured in the chuck which is turned by the electric motor. The chuck and drill bit are then lowered into the material by cranking the feed handle.

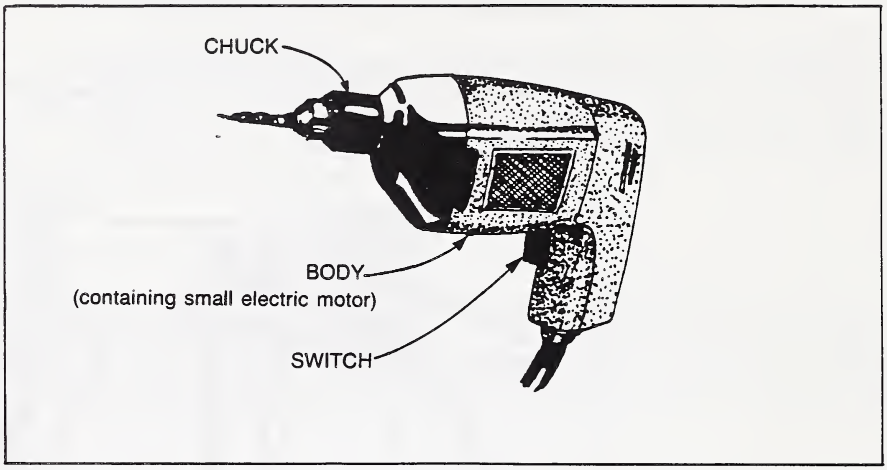


Safety Note:

(i) Goggles must be worn.
(ii) Secure all material before turning on the power.
(iii) Remove chips after drilling using brush and with the power turned off.

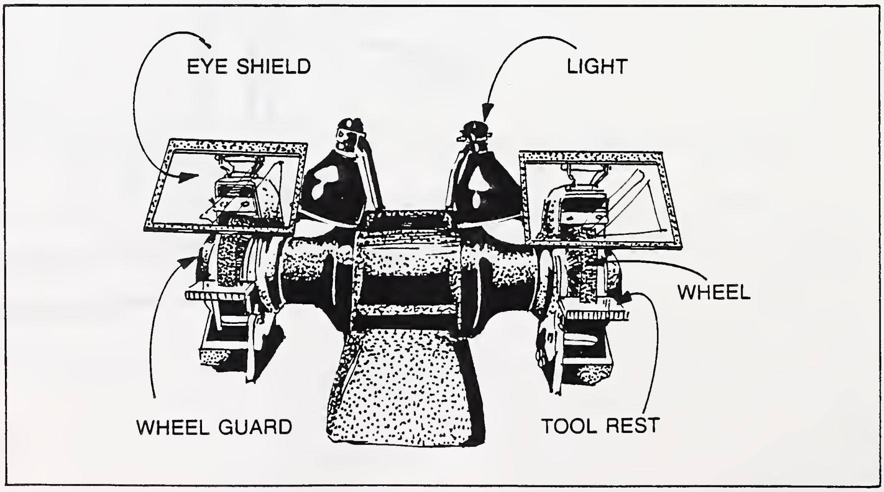
2. Portable Electric Drill

The portable electric drill is used for the same purpose as the drill press. Some of the procedures as well as the precautions mentioned above also apply.



3. Bench Grinders

The primary uses of a bench grinder include sharpening tools and removing stock from various parts. Often the bench grinder is fitted with a grinding wheel on one side and a wire wheel on the other. The wire wheel is used for cleaning parts.



An improperly used grinder is dangerous. It is responsible for many serious injuries to the eyes, hands, and face. **Always** observe the following safety rules:

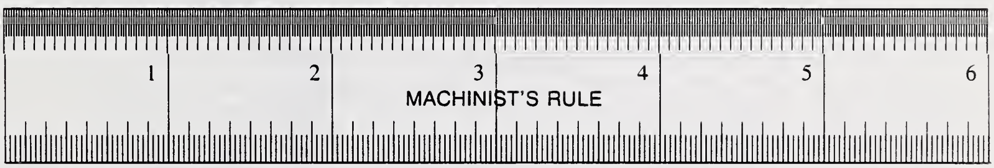
(a) Always wear goggles.
(b) Clean and tighten abraisive stones (wheels) regularly.
(c) Eye shields must be in place before using the grinder.
(d) Allow the grinder to reach full speed before applying material to the wheel.
(e) Keep the tool rest as close to the wheel as possible.
(f) Stand to the side of the stone as much as possible.
(g) To avoid flying objects, hold small objects with vise-grip pliers.
(h) Wear leather gloves for heavy grinding.

MEASURING INSTRUMENTS

Most jobs on small engines involve checking sizes, clearances, and adjustments. Inaccurate measurements can greatly affect the operation and performance of your engine. Thus, great care must be exercised when making all measurements.

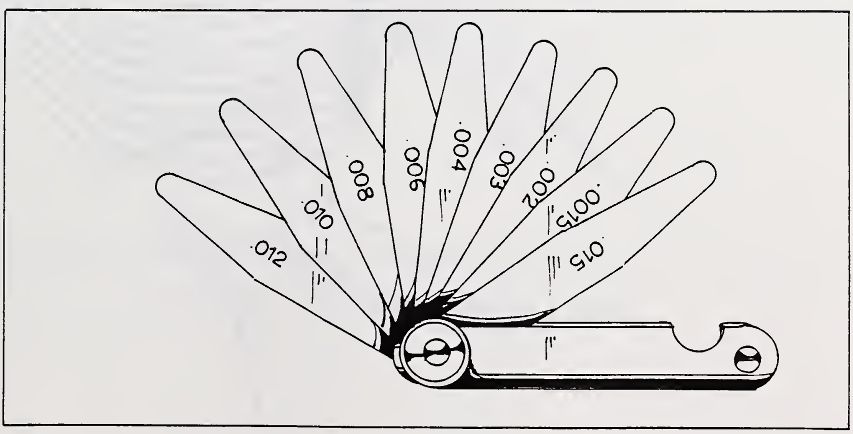
1. Steel Scales or Rule

The steel rule is the simplest of the measuring tools discussed in this lesson. It can be used for simple measurements and also to check for warpage of parts.



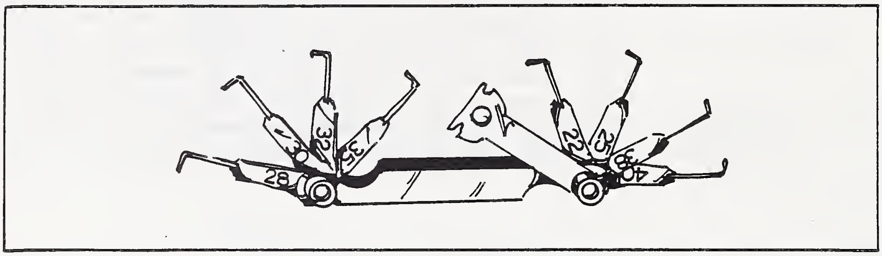
2. **Feeler Gauge** (Thickness Gauge)

The feeler gauge is ideal for measuring clearances, small gaps, and narrow slots. They are usually arranged in leaf form, each of which is marked for size.



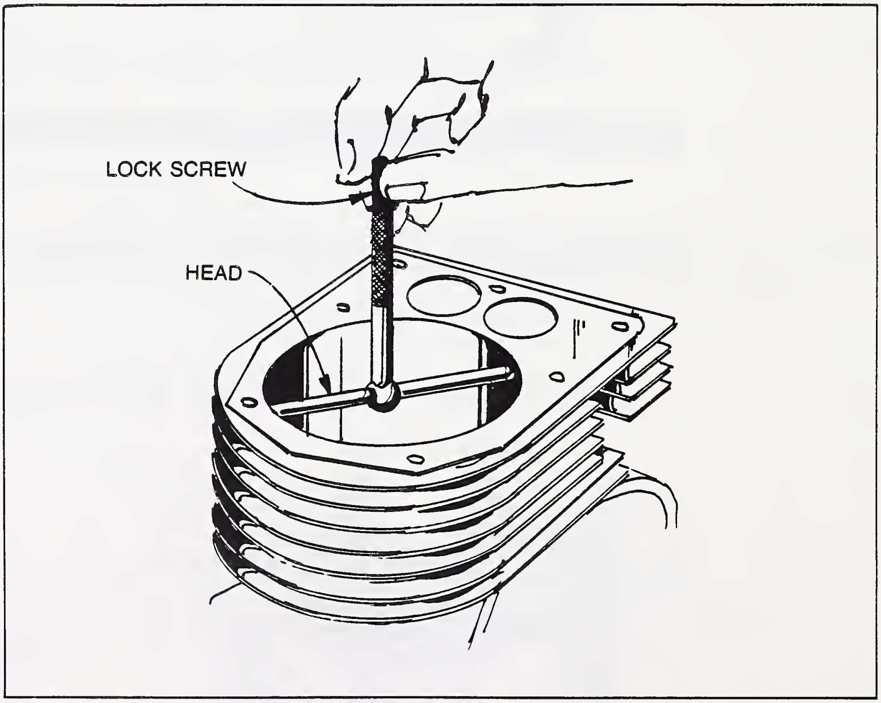
3. Wire Gauge

The wire gauge is a type of feeler gauge with wires of varying diameter instead of thin flat strips of steel as in the feeler gauge. The wire gauge is used for checking spark plug gap or ignition point gap.



4. Telescoping Gauge

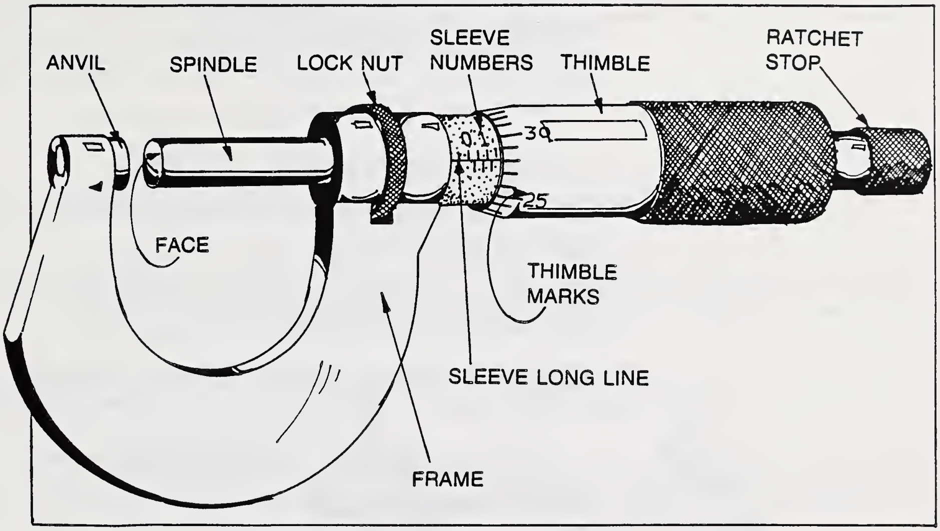
The telescoping gauge is used in conjunction with a micrometer for measuring inside bores of engine parts. The contact points compress and telescope within one another under spring tension. To obtain a measurement, insert the contacts into the bore and allow the contacts to expand. After the proper fitting has been made lock the contacts into position. Finally, remove the gauge from the bore and read your measurement with a micrometer.



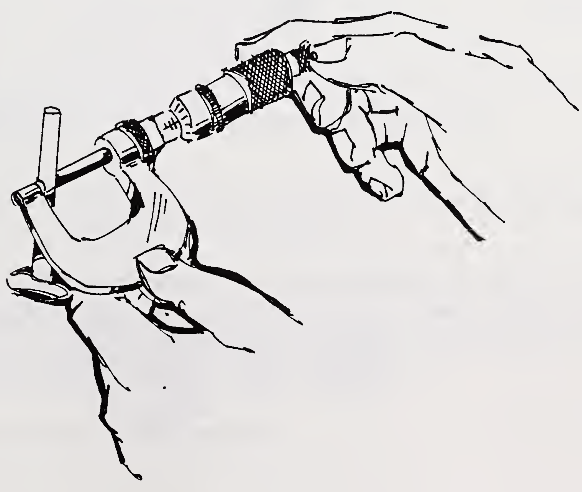
Fitting a telescoping gauge into a cylinder bore.

5. Micrometer

The outside micrometer is a precision measuring tool used to check diameters of crankshaft journals, wrist pins, shafts, etc. A micrometer is so accurate that it can be used to take measurements that are about one-thirtieth the thickness of a sheet of paper. Micrometers are made in many different sizes and types. Micrometers are available in metric as well as in imperial measurement.



To make a measurement, the micrometer should be clamped to the object at the point you wish to measure. It is extremely important that you do not clamp the micrometer tight on the object. One should be able to slip the object in and out of the micrometer while giving the thimble a final adjustment. Damage to the micrometer will occur if the work is clamped too tightly. Some miccrometers have a ratchet knob, which when used, will prevent overtightening.



(a) **Reading the Micrometer**

Above the sleeve long line (see diagram on page 17) the sleeve is divided into millimetres from 0 to 25 mm. Below the sleeve long line each millimetre is subdivided into one half of a millimetre (0.5 mm). Therefore, two complete turns of the thimble changes the distance between the anvil and the spindle one millimetre.

The thimble is divided into 50 divisions with every fifth line numbered. The numbers occur in multiples of five (i.e. 0, 5, 10, 15, ... 50). Since one complete revolution of the thimble moves the spindle 0.5 mm, each division on the thimble equals 1/50 of 0.5 mm. In other words, each division is equal to 0.01 mm, two divisions equal 0.02 mm, and so on.

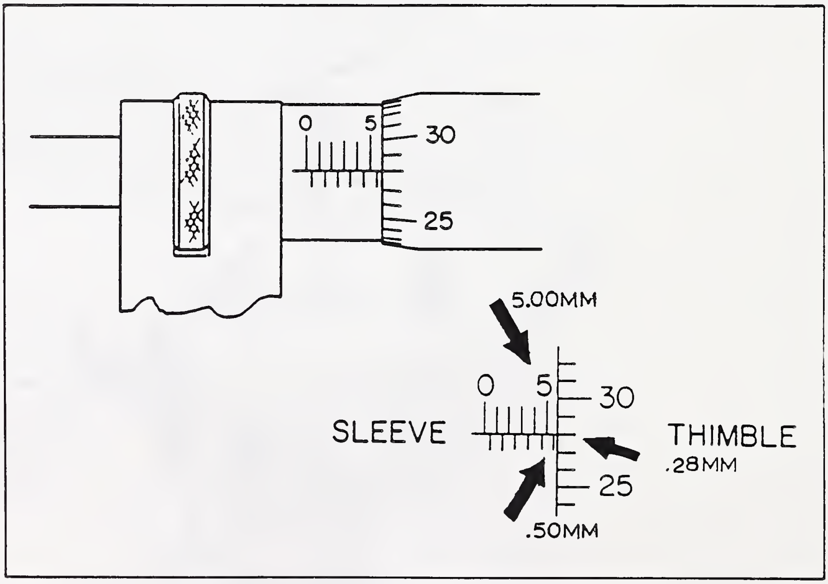
To read a micrometer follow these steps:

Step One: Note the reading in millimetres visable on the sleeve. (Numbered lines above the sleeve long line.)

Step Two: Add to this any 0.50 mm which may be visible on the sleeve. (Shorter lines below the sleeve long line.)

Step Three: Add to the reading the number in hundredths of a millimetre indicated by the division on the thimble which coincides with the sleeve long line.

These steps are shown in the following example:



Step 1: 5.00 Sleeve reading in whole millimetres
Step 2: 0.50 Half millimetre.
Step 3: 0.28 Thimble reading in hundredths of a millimetre
5.78 mm Add to get the reading.

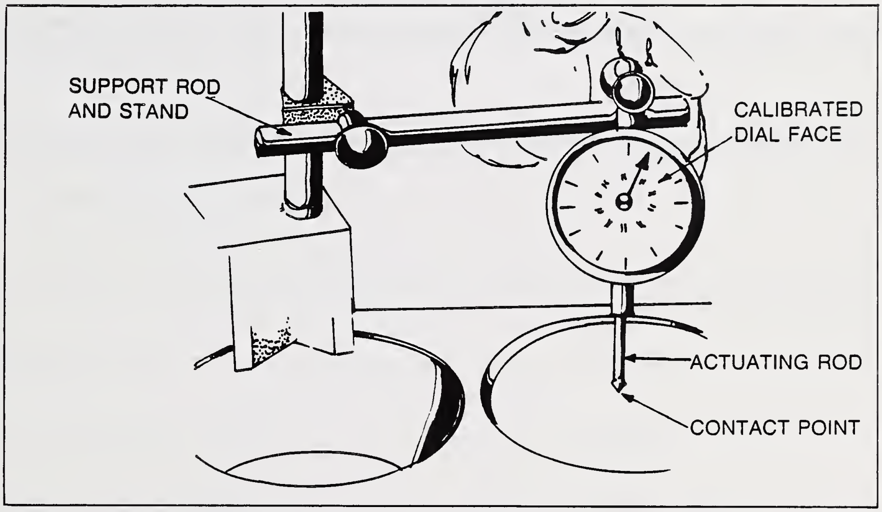
(b) Caring for Micrometers

- (i) Do not place micrometers where they are subject to heat.
- (ii) Periodically check micrometers with a standard to ensure accuracy.
- (iii) Store micrometers in their cases or boxes.
- (iv) Clean a micrometer frequently with a clean cloth oiled with a few drops of machine oil.
- (v) Be sure that the contact faces are clean before making a measurement.
- (vi) Avoid dropping a micrometer. If the micrometer is accidently dropped have its accuracy checked using a standard.

6. Dial Indicator or Gauge

The dial indicator is used for checking amd measuring end play in shafts, backlash between gears, valve lift, taper in cylinders, and determining piston top dead centre.

The face of the dial indicator is calibrated in hundredths of a millimetre. The distance over which the indicator can be used vary with the type of instrument used. Since the indicator is used on various setups, swivels, adaptors, and mounting arms are supplied with each unit.

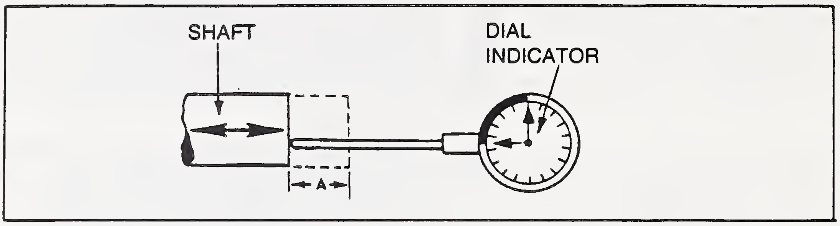


Using the dial indicator to determine piston top dead center.

When using a dial indicator, f'rmly mount the unit so that the actuating rod is parallel to the direction of movement to be measured.

Place the contact point against the work to be measured. Then push the indicator toward the work causing the needle to travel for enough around the dial so that movement of the work in either direction will result in needle deflection. Turn the dial face to line the zero (0) mark with the indicator needle.

The following diagram demonstrates the use of a dial indicator to measure end play (movement) of a shaft through a distance marked as A.



CARE AND MAINTENANCE OF TOOLS

(a) Tools should be kept clean, orderly, and close at hand.
(b) Delicate measuring tools should be placed in protective cases or boxes.
(c) Separate cutting tools (such as files, drills, chisels, etc.) from other tools to prevent damage to their cutting edges as well as damage to other tools.
(d) Tools are subject to rusting. To avoid rust, lightly coat each tool with a rag containing a few drops of machine oil.
(e) Place heavy tools in a location by themselves.
(f) Keep cutting tools sharp.
(g) Use all tools with care and follow all safety recommendations.

Complete the following questions and send them in for correction.

1. What two factors will determine the kind of tools to purchase?

   (a) ______________________________

   (b) ______________________________

2. All present day tools are rustproof. (True or False) ______________

3. Three uses for hammers in small engine repair are:

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

4. The ____________ ____________ is used to mark the spot where a drill bit will start to cut.

5. Pliers are useful to tighten nuts when the proper sized wrench is not available. (True or False) __________

6. The name given to the screwdriver with a star-shaped tip is ____________.

7. Taps are used to cut ______________ threads.

8. Dies are used to cut ______________ threads.

9. What procedure should be followed in order to prevent bruised knuckles when working with wrenches?

   ____

10. Better quality drills are made of ____________ ____________ ____________.

11. One should always wear ______________ when working with a hammer and chisel.

12. An ____________ ____________ is a tool specifically designed to free stuck bolts and frozen screws.

13. Why is so much emphasis placed on selecting the correct-sized screwdriver?

____

____

____

14. **Why is it important to keep tools maintained?**

____

____

____

15. Why should a mushroomed head be ground off a chisel?

____

16. Why is it safer to wash dirty parts in cleaning solvent than in gasoline?

____

____

____

17. The part of a drill press or portable electric drill in which the drill bit is secured in is the ______________________.

18. When grinding, never allow the tool rest to get close to the abrasive wheel. (True or False)

____

19. A thickness gauge is ideal for checking spark plug gap. (True or False)

____

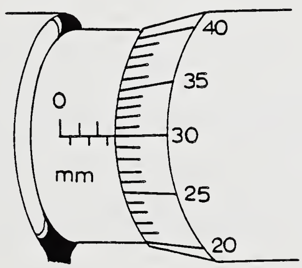
20. A telescoping gauge is usually used in conjunction with a: (underline the correct choice)

(a) dial indictor.
(b) steel rule.
(c) outside micrometer.
(d) feeler gauge.

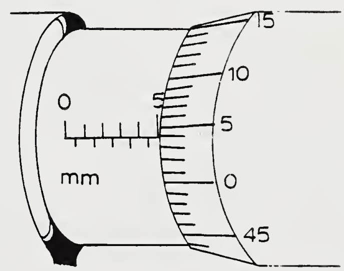
21. Soft faced hammers are used rather than steel hammers because they: (underline correct choice)

(a) apply softer blows.
(b) are quieter.
(c) jar the hand less.
(d) protect machined surfaces.

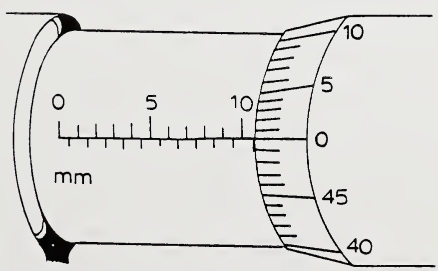
22. Find the following metric outside micrometer readings.



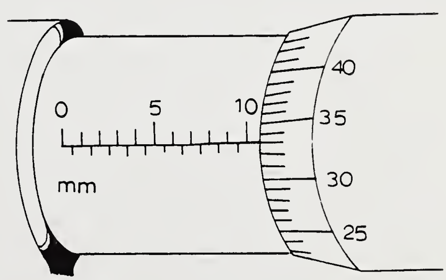
(a) ______________________



(b) ______________________



(c) ______________________



(d) ______________________

END OF LESSON 1

QUESTIONNAIRE FOR SMALL GASOLINE ENGINES

Please give us the following information (printed).

1. Name ____________________ Age __________

   Address ______________________________ Postal Code __________

   Town or City ______________________ Phone Number __________

2. List any other courses or modules you are taking by correspondence.

   ____

   ____

3. How did you find out about this course?

   ____

4. Do you have a small engine to work on? ____________________

   Make ____________ Model ____________ Year ____________

   Used for ____

   Do you have a shop manual? ________________________________

5. What other course(s) would you like to see by Correspondence?

   ____

   ____

LESSON RECORD FORM

5037 Small Engines

Revised 91/09

FOR STUDENT USE ONLY	
Date Lesson Submitted ____________	(If label is missing or incorrect)
Time Spent on Lesson ____________	File Number ____________
	Lesson Number ____________

FOR A.D.L.C. USE ONLY

Assigned Teacher: ____________

Lesson Grading: ________

Additional Grading E/R/P Code: ________

Mark: ____________

Graded by: ____________

Assignment Code: ______

Date Lesson Received:

____

Lesson Recorded ________

Student's Questions and Comments

Apply Lesson Label Here

Name

Address

Postal Code

Please verify that preprinted label is for correct course and lesson.

Teacher's Comments:

____

Correspondence Teacher

St. Serv. 14-91

ALBERTA DISTANCE LEARNING CENTRE

MAILING INSTRUCTIONS FOR CORRESPONDENCE LESSONS

1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do not enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

First Class

Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

BASIC PRINCIPLES OF OPERATION

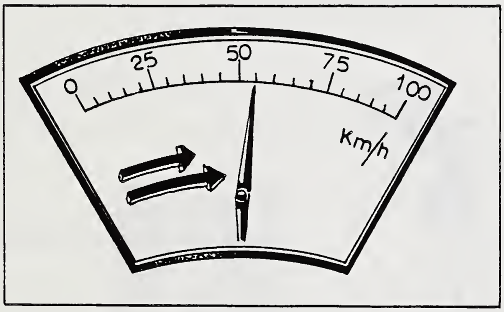
INTRODUCTION

Engines may be classified in several ways. They may be classified by the number of cylinders (single cylinders, twin cylinder, etc.), the position of cylinders (horizontally, opposed, V-arrangement, vertical, etc.), and also by the cylinder head arrangement (such as F-head, L-head, and T-head). They can be further classified as either liquid-cooled or air-cooled. Another classification is by cycle (which is the number of strokes the piston makes for each completed cycle) i.e. two cycle, four cycle.

Many technical terms are used in engine manufacture and maintenance or repair. These must be part of the students' vocabulary if the student is to gain an understanding of engine theory and operation. Following is a pictorial list of the more common terms which you should be familiar with. All of these definitions should be studied.

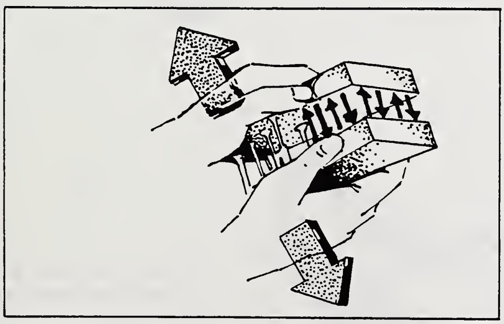
TERMS

Acceleration



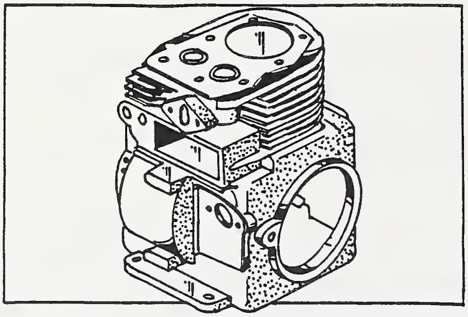
The rate at which the velocity or speed changes, measured in m/s^2.

Adhesion



The tendency for one surface of a substance to stick to another surface.

Air Cooled Engine



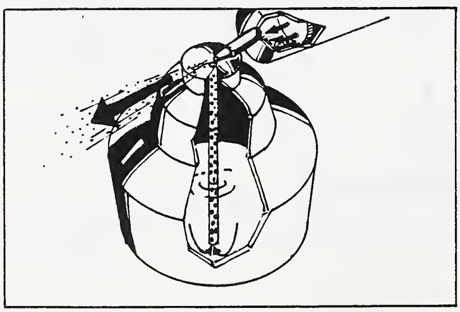
Has cylinders finned to dissipate engine heat into surrounding air.

Ampere

$$\text{Ampere (A)} = \frac{\text{Electromotive Force}}{\text{Resistance}} = \frac{\text{Volts}}{\text{ohms}} = \frac{V}{\Omega}$$

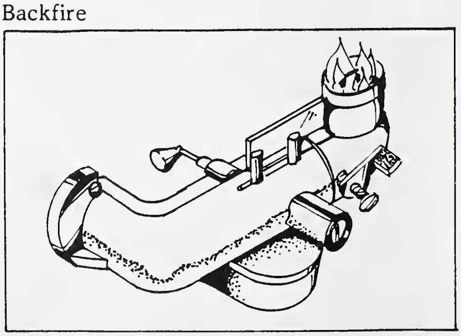
Measures the flow of electric current.

Atomize



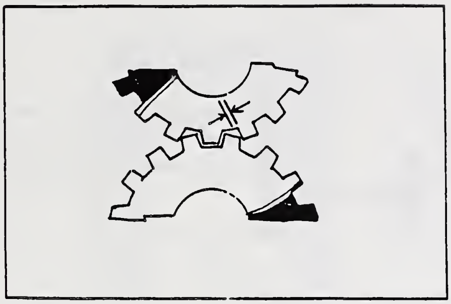
To break up a liquid into a fine spray.

Backfire



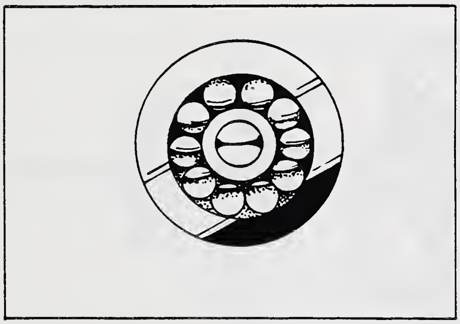
When the gas ignites before entering the combustion chamber and flows back out the carburetor.

Backlash



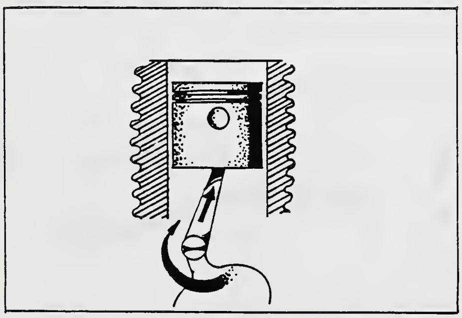
Measured as the amount of play between matching gear teeth

Ball Bearing



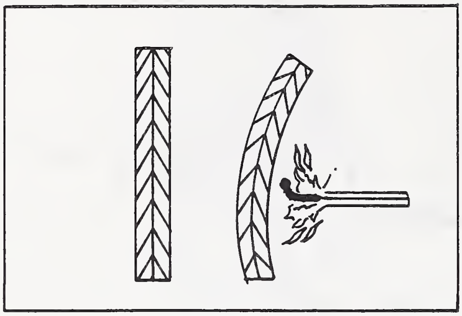
An antifriction device composed of inner and outer hardened steel supports separated by a number of hardened steel balls.

Before-top-dead-center



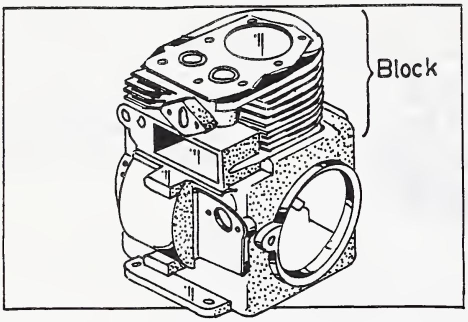
That period of time just before the connecting rod is parallel with the cylinder walls at the top of a stroke.

Bimetal Device



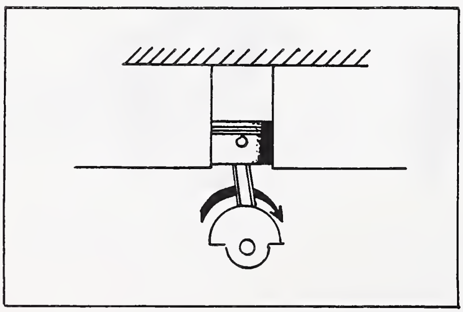
A device made of two metals which expand and contract at different rates with temperature changes.

Block



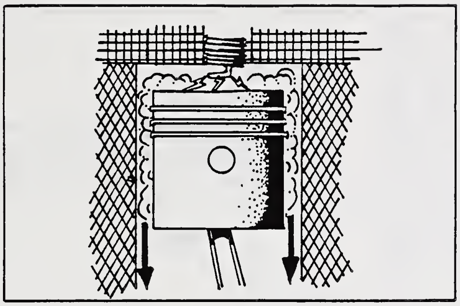
Part of the engine that contains the cylinder(s).

Bottom Dead Center (BDC)



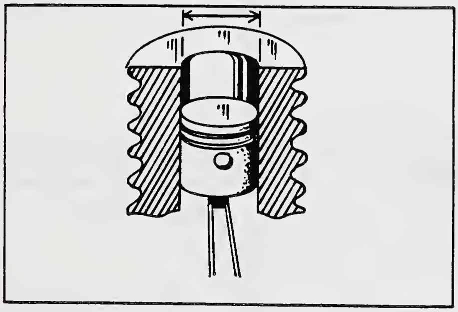
The piston is at the bottom of its stroke.

Blow-by



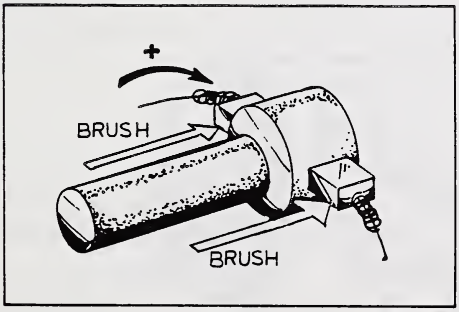
When rings etc, do not fit tight enough and allow leakage from the combustion chamber into the crankcase.

Bore (cylinder)



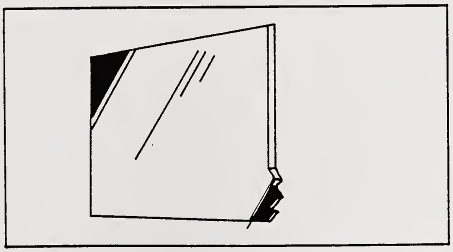
The diameter of the cylinder, usually in millimetres or centimetres.

Brush (electrical)



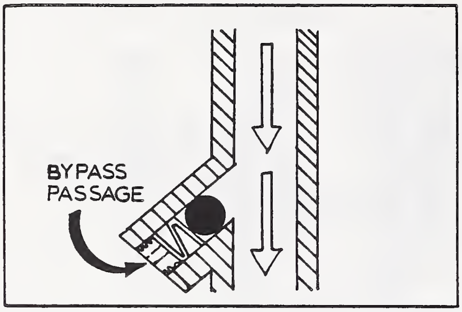
Pieces of carbon or copper used as moveable electrical contact points.

Burr



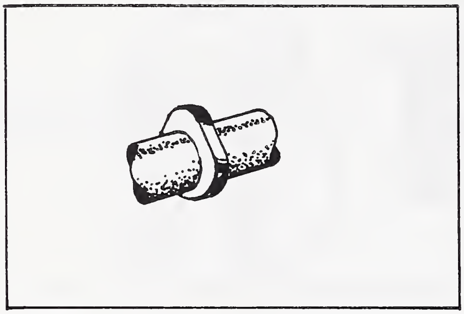
A thin rough edge left on a piece of metal after being ground or filed.

By-pass



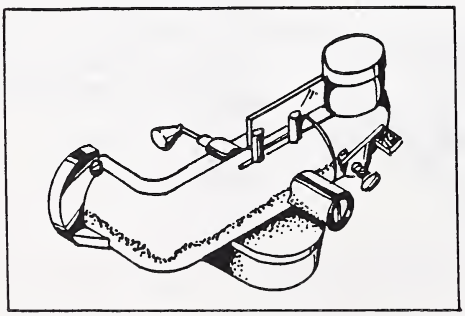
A passage usually controlled by a pressure valve to allow an alternate route for movement of liquids and vapours.

Cam



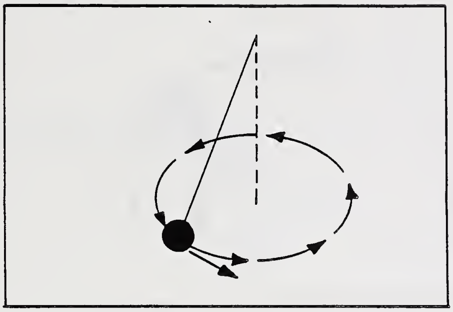
An off-round projection from a shaft used to move or lift another part at specific times during rotation.

Carburetor



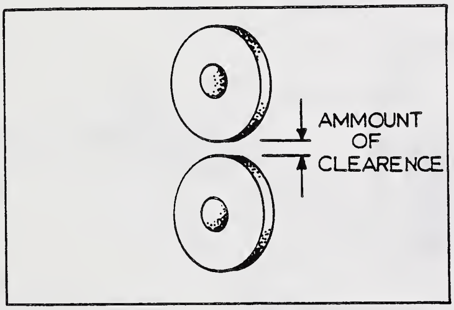
Measuring device that meters, atomizes and mixes fuel with air as it comes into the engine.

Centrifugal Force



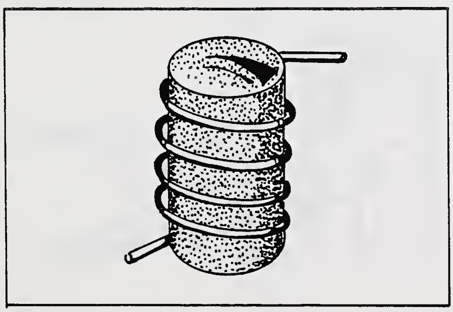
That force tends to make a moving object try to travel in a straight line.

Clearance



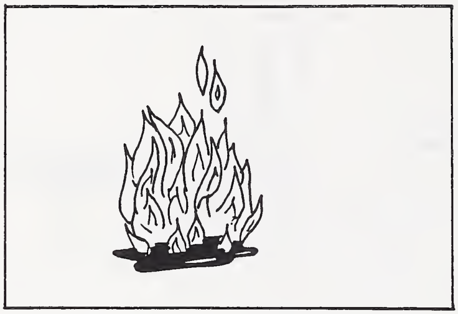
The amount of space between two adjacent parts.

Coil



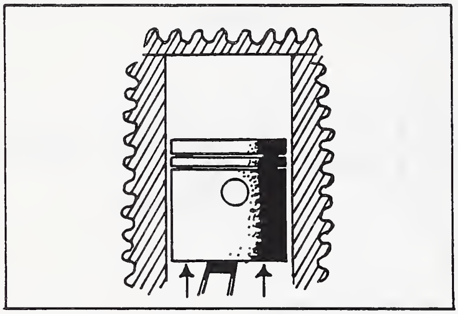
Wire forming a series of loops, usually with an iron case to create an electric magnet.

Combustion



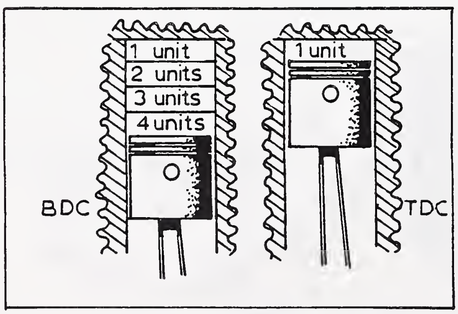
The act or process of burning anything.

Compression



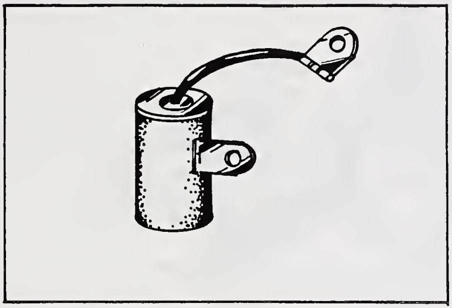
The squeezing of something into a smaller volume.

Compression ratio



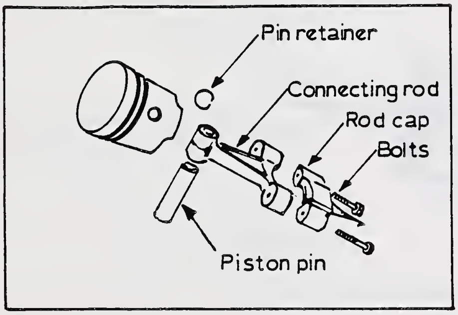
The volume at BDC to the volume at TDC, in this case 4:1.

Condenser



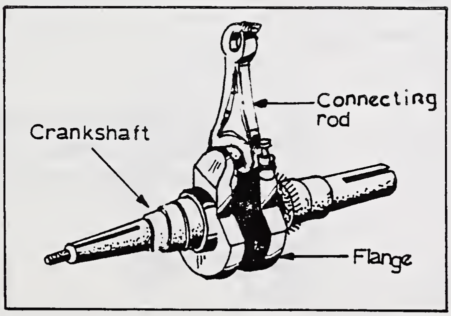
An electrical device used to absorb surges of electricity which prevents arcing at the breaker points.

Connecting Rod



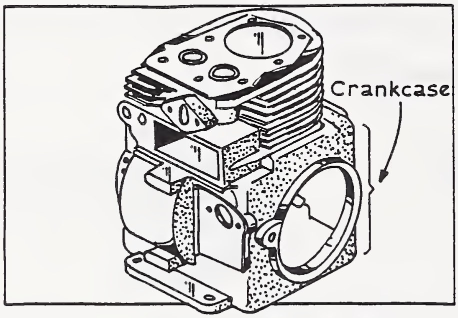
The unit that connects the piston to the crankshaft.

Counter weight



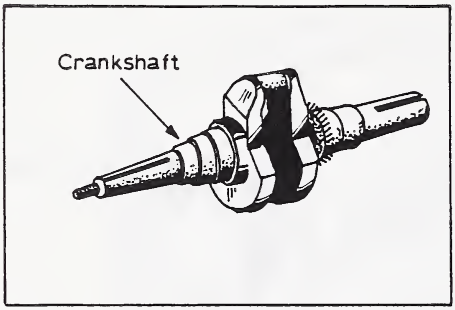
The forged flange on a shaft used to balance an offset load such as the flange on a crankshaft opposite the connecting rod.

Crankcase



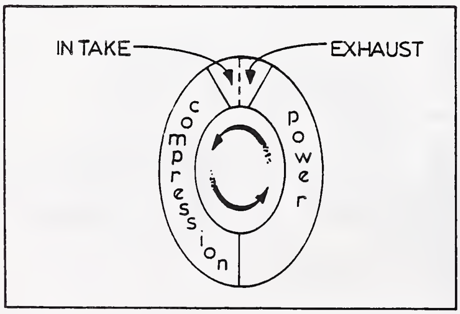
The part of the engine block that contains the crankshaft.

Chankshaft



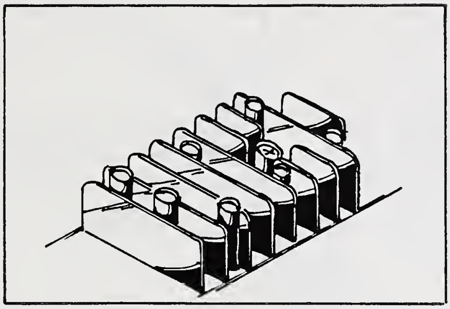
Engine's main shaft with throws (offsets) to which the connecting rod(s) are attached.

Cycle



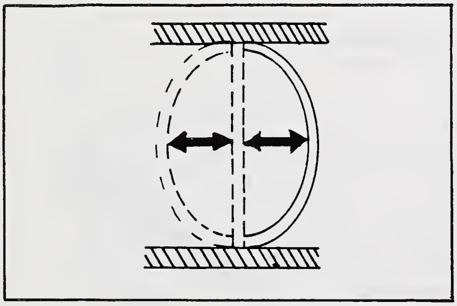
The completion of a series of events that keep repeating. Depicted in the diagram to the left is one complete cycle of a 2-stroke-cycle engine.

Cylinder Head



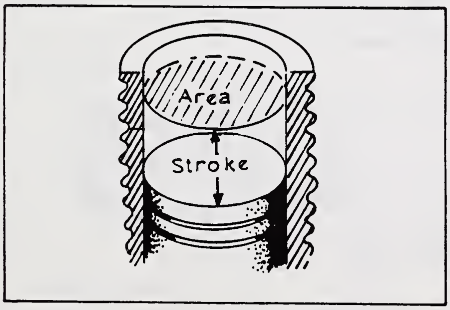
A detachable metal portion of an engine bolted to the top of a cylinder block.

Diaphragm



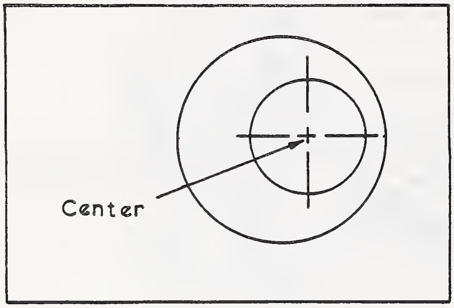
A stationary dish or a partition which can flex out in the center while the edges remain stationary.

Displacement



Displacement of an engine, is the cross-secitonal area of a cylinder, times the length of the piston stroke, times the number of cylinders in the engine.

Eccentric

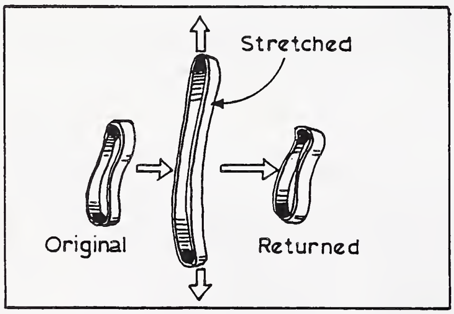


A portion of a rotating shaft which is placed off center. Camshafts contain eccentrices to open and close valves.

Efficiency

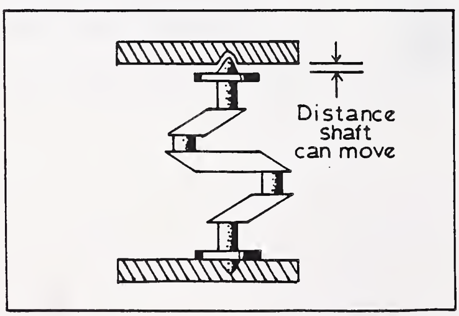
$$\frac{\text{Work performed by an engine.}}{\text{Energy expanded in producing the work.}} = \text{Efficiency Ratio}$$

Elasticity



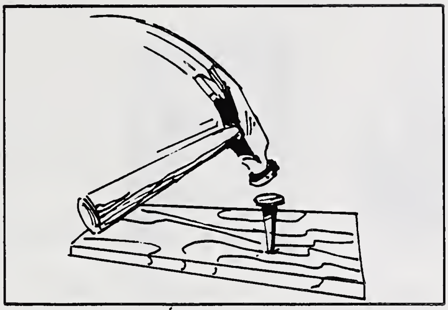
The property of a substance to return to its original size and shape after being stretched or deformed by an external force.

End Play



The amount of movement that a shaft can make, along the axis of such a shaft.

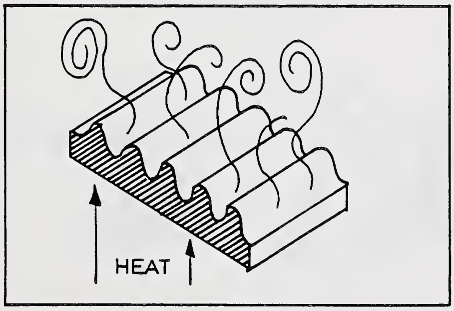
Energy



A force capable of doing work.

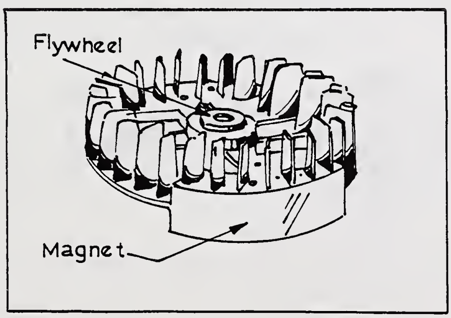
Energy about to be expended.

Fin



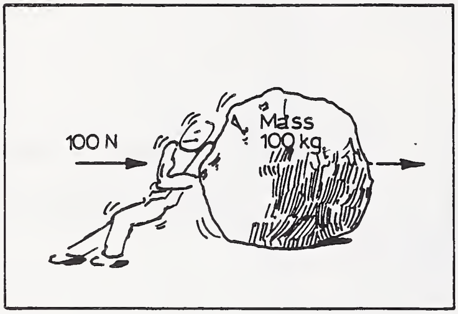
One of a series of projections from the surface, designed to increase the surface area and aid in heat transfer from the surface to the air.

Flywheel



A heavy, balanced wheel attached to the crankshaft. It absorbs and stores energy through momentum; smooths engine operation; and may aid in cooling the engine.

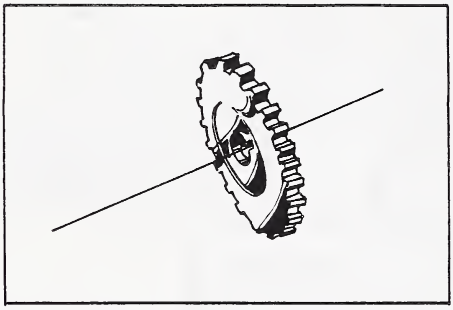
Force



$F = ma$
$= 100 \text{ kg} \times (1 \text{ m/s}^2)$
$= 100 \text{ kg m/s}^2$
$= 100 \text{ N}$
N = Newton, the unit of force

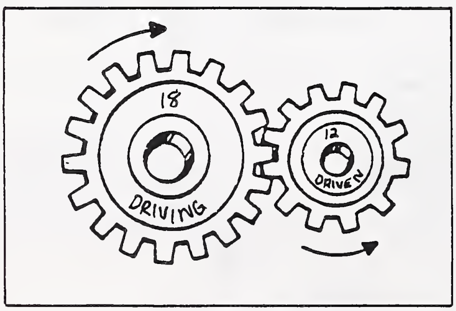
accelerating 1 m/s^2

Gear



A wheel shaped part that has teeth cut into it.

Gear Ratio

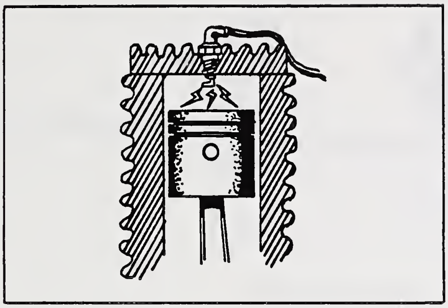


The number of teeth on the driving gear to the number of teeth on the driven gear.

i.e. 18:12
= 1.5:1

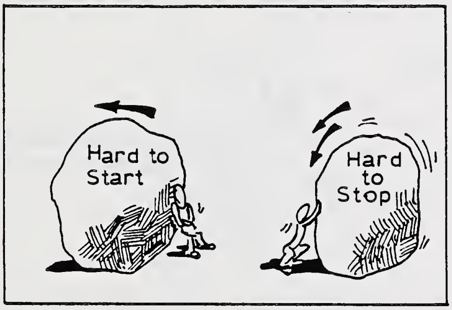
always reduce the ratio.

Ignition



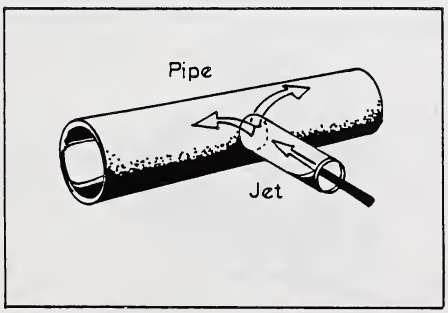
The act of firing a combustible mixture.

Inertia



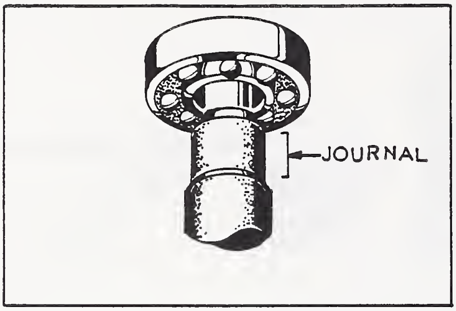
The tendency of objects to remain in a steady state unless external forces are applied.

Jet



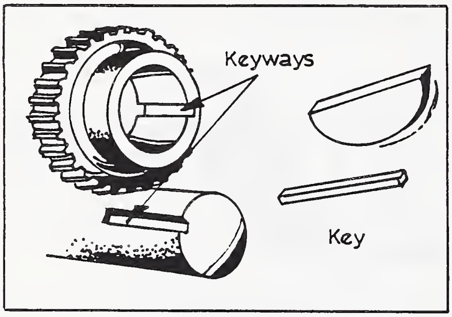
A small, tube-like device through which substances flow.

Journal



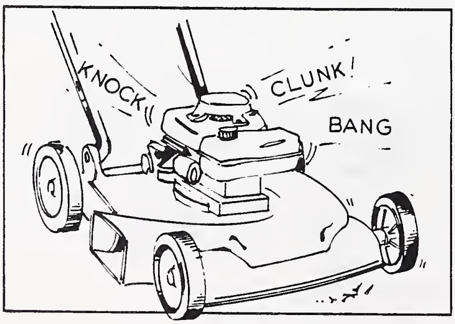
A shaft machined down to snugly fit a bearing.

Key



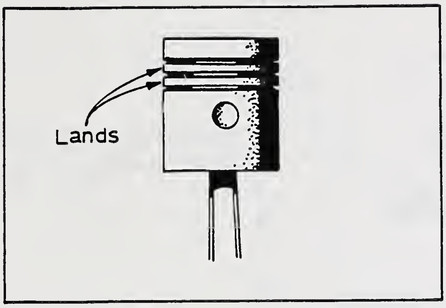
A small piece of metal inserted between a shaft and a hub to prevent the hub from rotating on the shaft.

Knocking



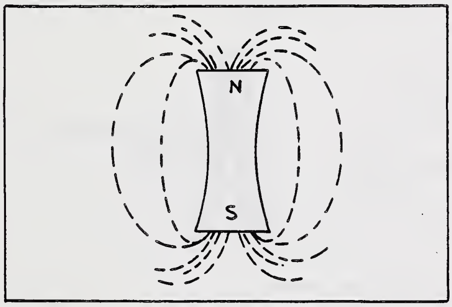
Sound made by engine when fuel burns too fast or unevenly. Also noise made by loose or worn parts.

Lands



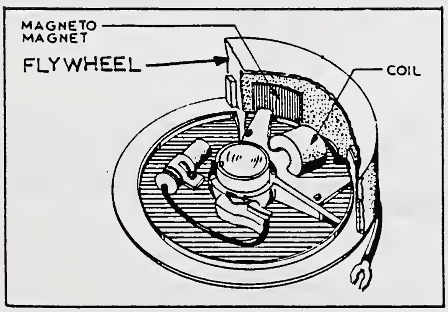
The ridges of metal between the ring grooves on a piston.

Magnetic Flux



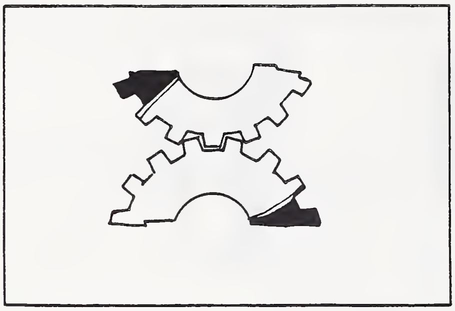
The invisible force lines surrounding all magnets.

Magneto



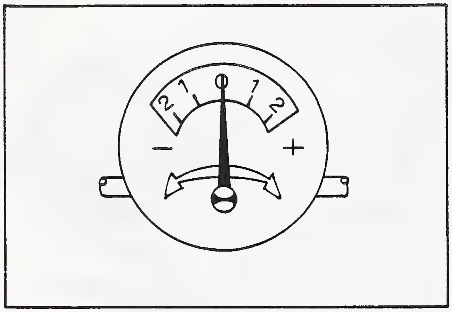
A device used to convert mechanical energy to electrical energy through the process known as electromagnetic induction. Usually flywheel mounted on small engines.

Mesh



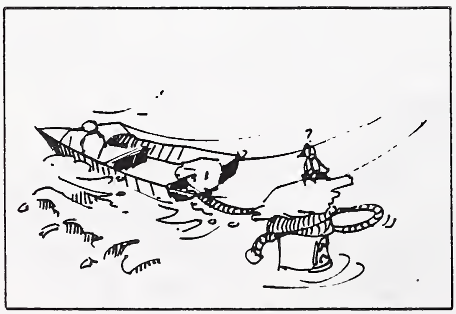
The proper fitting of the teeth on one gear with those on another gear.

Meter



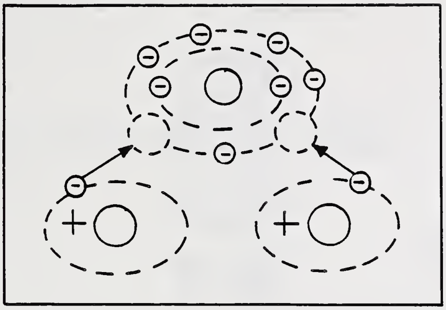
A device used to measure the flow of something.

Momentum



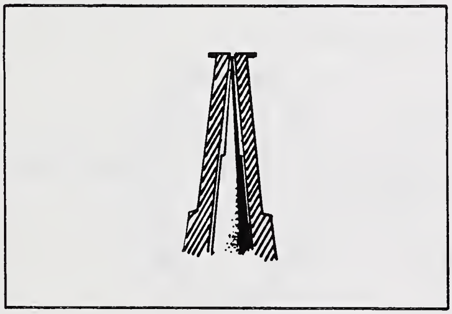
A quantity of motion: that property of a moving body which determines the force and time required to stop its movement.

Molecule



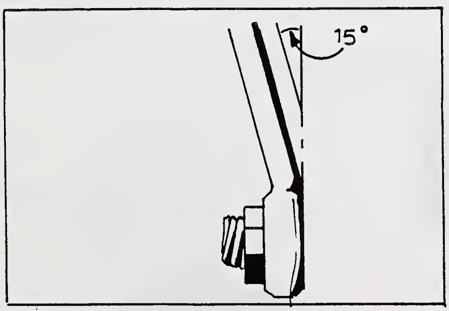
Considered the smallest subdivision of a compound which still has all the properties of that compound.

Nozzle



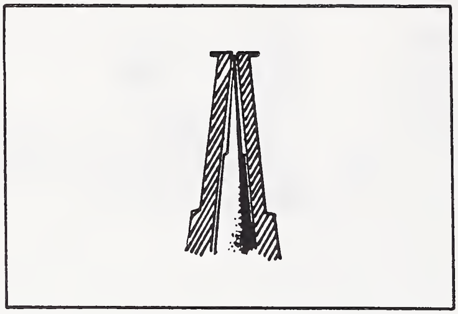
A device used to discharge a gas or fluid in a directed flow.

Offset



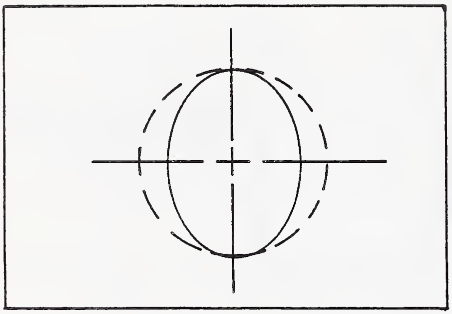
Placed to one side of center or the center line. This is an example of a 15° offset wrench.

Orifice



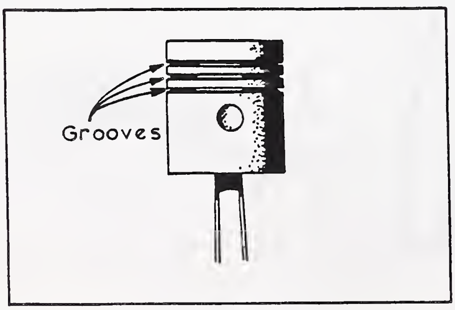
A small opening in a noozle, or jet.

Out-of-Round



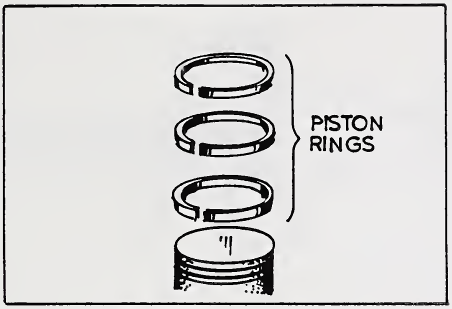
Is not a proper circle.

Piston



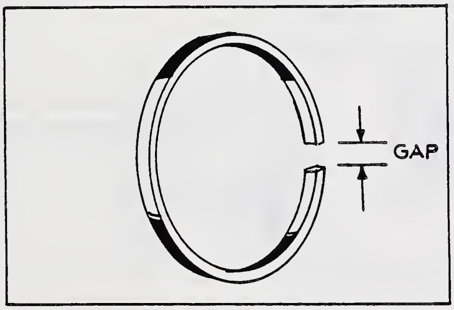
A cylindrical part closed at one end, which fits in the cylinder.

Piston Rings



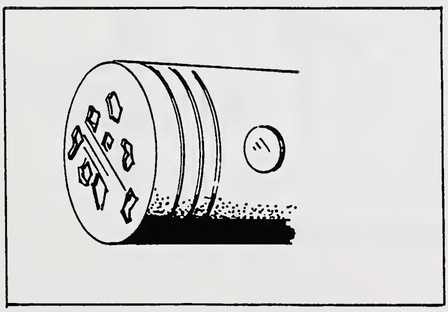
A split, expanding ring placed in grooves of a piston to provide a seal to prevent combustion gases from leaking to the crankcase.

Piston Ring Gap



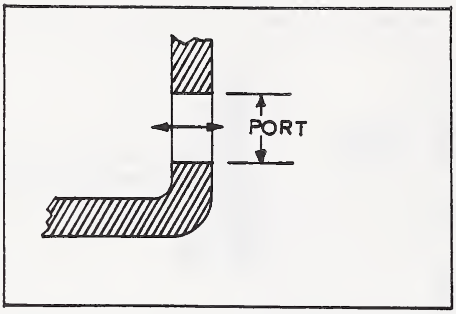
The space left in piston ring. Note they are never a closed circle when installed. The space allows for expansion due to heat. Piston rings expand when heated and the gap decreases.

Pitted



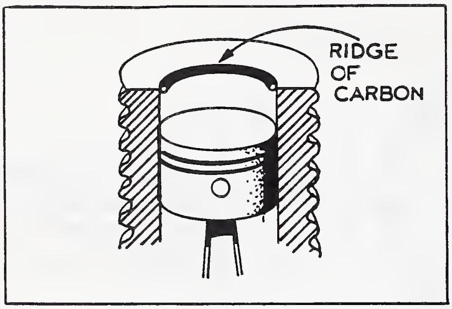
Having small depressions of material missing from a surface.

Port



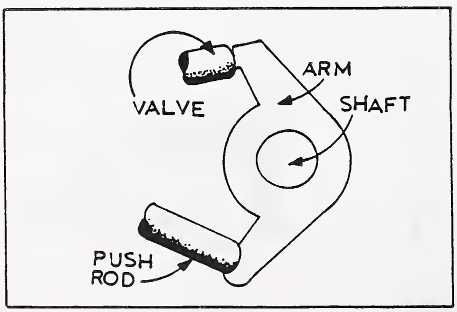
The opening in a solid part through which something is allowed to flow in or out.

Ridge



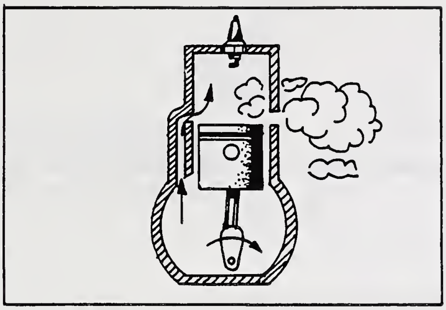
A narrow raised rib or strip on cylinder blocks. It must be removed before a piston is removed.

Rocker Arm



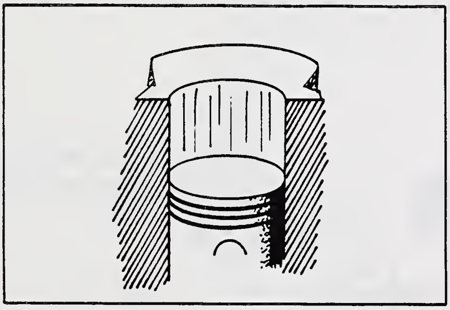
A device used to reverse an upward motion into a downward motion. Usually used in opening valves.

Scavenge



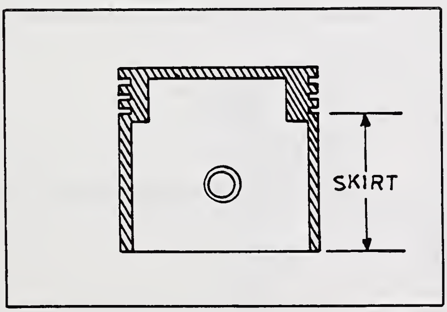
A cleaning or blowing out action in the combustion chamber as exhaust gases are replaced by intake fuel mixture.

Scoring



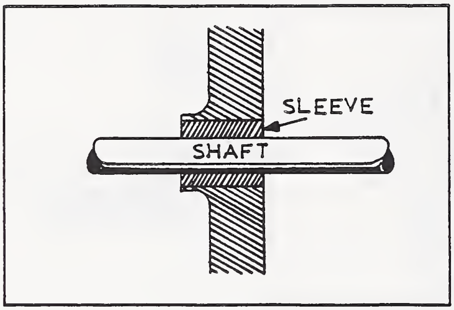
The scratches and grooves created from moving parts against stationary parts.

Skirt



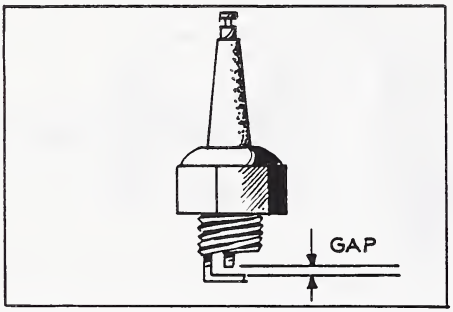
The lower part of a piston which gives it stability.

Sleeve



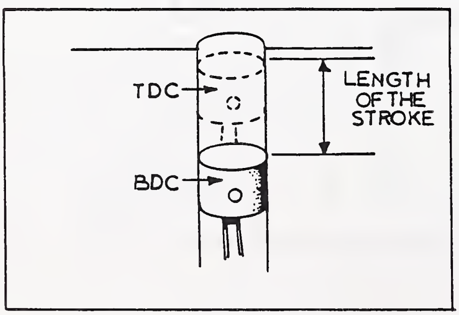
An insert usually used when wear is excessive and the sleeve can be replaced without total replacement of the whole unit.

Spark Gap



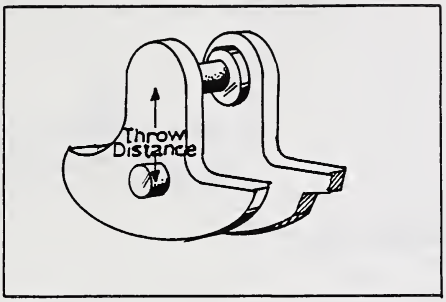
The air gab between the electrodes across which the electrical charge must jump creating a spark.

Stroke



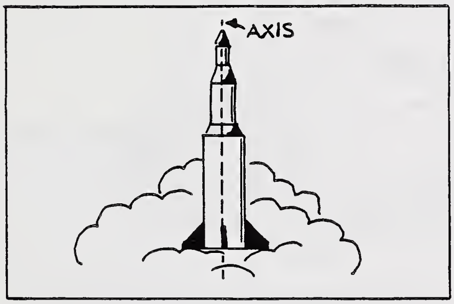
The length of piston travel from BDC to TDC.

Throw



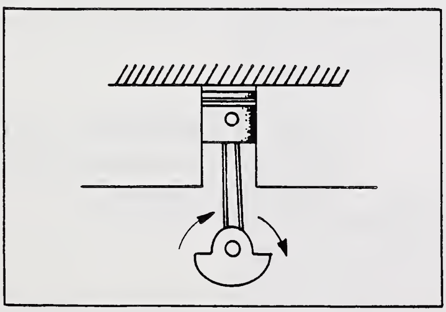
The distance from the center of the crankshaft to the center of the connecting rod journal.

Thrust



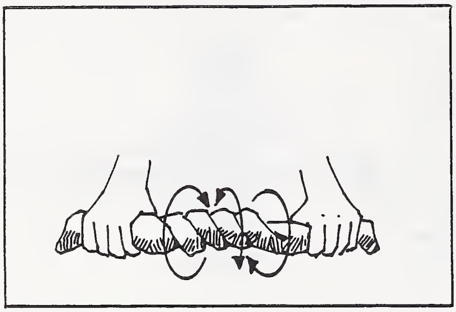
A force directed along the axis of a part.

Top Dead Center (TDC)



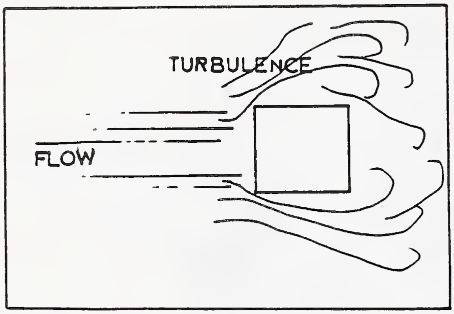
That position of the piston when the connecting rod is perpendicular to the crankshaft and the piston is at its highest point.

Torque



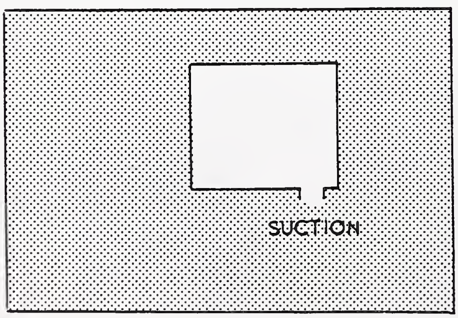
That force which is produced by rotary effort and measured in multiple and submultiples of the (N · m) Newton metre.

Turbulence



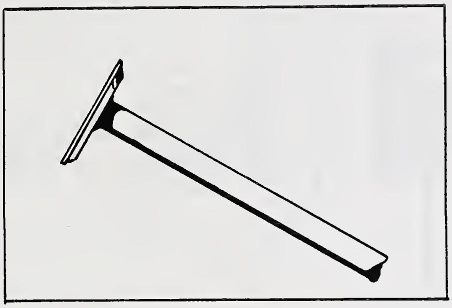
A disturbance to the normal flow pattern.

Vacuum



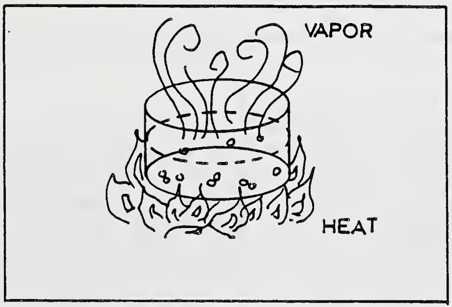
A space which is void of all matter or reduced to a pressure less than atmospheric. Measured in pascals (Pa).

Valve



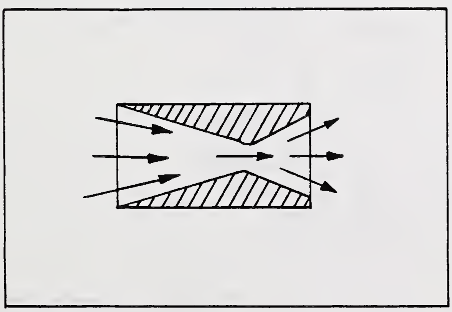
A device used to regulate a flow.

Vaporize



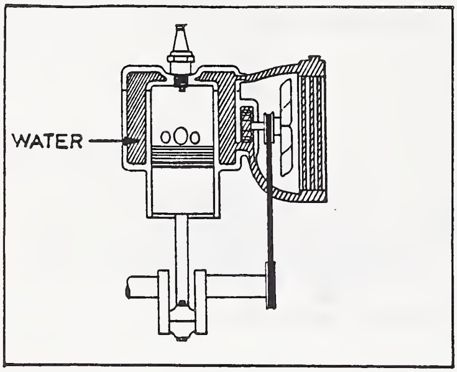
To change a liquid to a gaseous form.

Venturi



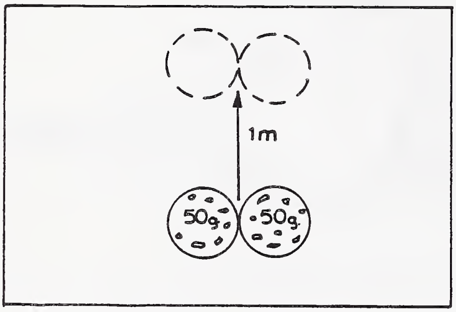
A restriction or narrowing of a passage.

Water Cooled Engine



A engine that circulates water around the cylinder to dissipate the excess heat of combustion.

Work



The amount of energy expended over a period of time. Measured in joules (J). Note: $1J = 1N \cdot m$
Example: if 2 golf balls are lifted to a height of 1 m, then 1J of work has to be done.

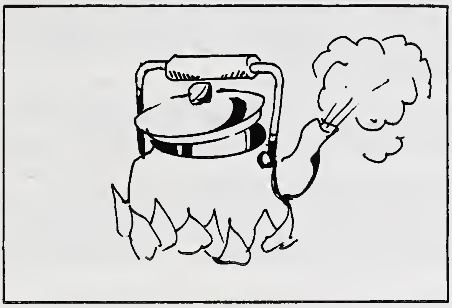
PHYSICAL PRINCIPLES

Combustion Engines

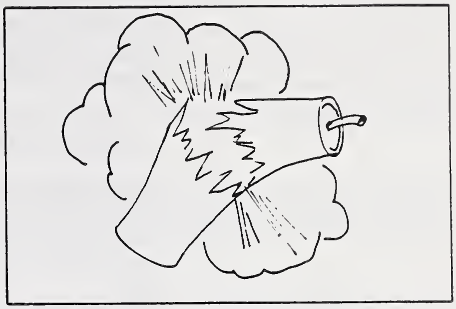
Combustion may be defined as an act of burning. A combustion engine is one that uses the heat energy of a burning fuel. There are two types of combustion engines; external combustion engines and internal combustion engines.

The external combustion engine uses heat energy that is released from a fuel which is burned outside of the engine itself. An example of this type of an engine is the steam engine. The fuel is burned outside the actual engine in a boiler.

An internal combustion engine burns its fuel inside the engine itself. The heat energy is directly converted to mechanical energy.



External Combustion.

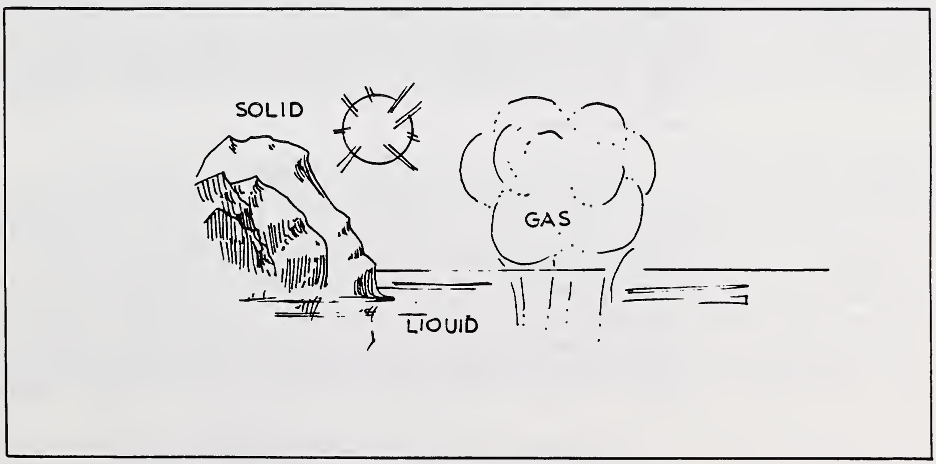


Internal Combustion.

The States of Matter

There are three states of matter: solid, liquid, and gas. The only major difference between these three states is the freedom of movement of the molecules that make up this substance. The movement of the molecules in all three states is caused by their own heat energy, or the heat energy generated through the collisions of these moving molecules. By increasing the kinetic energy of the molecules, one can change the substance from a solid to a liquid. If this energy is increased further the substance will become gaseous.

There are exceptions to this because some substances can not be changed from state to state due to the exceptionally large quantities of energy that would be required.



Three States of Matter

If we also increase the pressure of a substance we will cause more collisions between molecules to take place and this will generate more heat energy. Thus achieving the same result as previously stated. Water will suffice as a good example. It is a solid (ice) at temperatures below 0°C, a liquid from 0° to 100°C and a gas (steam) above this temperature (at atmospheric pressure). As pressure changes these temperatures also change by corresponding amounts.

A gas can be compressed and its volume made smaller. When a gas is compressed, or when the volume containing the gas is decreased, the pressure of the gas against the container is greater and the gas becomes hotter. But when the volume is increased the gas expands to fill the new volume thus the pressure and tempurature are lowered. Since energy is never lost but can be changed from one form to another a relationship is established between pressure, temperature, and volume, which is called the "Gas Law."

Pressure, Volume, and Temperature

In the gaseous state, the material is less dense than in liquid and solid states. The pressure of the gas can be assumed to be the result of the force of the molecules colliding with the walls of the container. If the same number of molecules are contained in a smaller space, then the number of collisions for any given area will be greater, so the pressure is greater. Conversely, when the same amount of gas is in a larger container then the number of collisions will be less and therefore the pressure is less.

Assuming that the heat of any substance is solely due to the collisions between molecules generating energy, then it can be seen that as the pressure or force on the gas increases, or the volume of the container decreases then the increase in number of collisions must increase the temperature of the substance. Conversely, it is logical that if we apply energy or heat to a substance, the molecules must move faster and faster. This increse in speed must also increase the frequency of the collisions if we hold the volume constant. But if the volume can increase, the increase in collisions will cause an expansion of the volume. The frequency of collisions will be reduced as expansion continues and the temperature will drop. Since the gaseous state of matter is not a defined form, the gas will always fill the available space.

It is a characteristic of molecules in liquids and gases, since they are not well defined forms, to move in all directions until they are spread evenly through the available space. This is also known as diffusion and could be defined as the movement of molecules from a region of high pressure to a region of lower pressure due to their own kinetic energy. This physical process of diffusion has many applications which are fundamental to the understanding of combustion engines. If two containers of gas at different pressures are connected together and a port is opened connecting them, then the gas under higher pressure will push into the lower pressure container until the pressures are equal. This is the concept that pushes the air-fuel mixture into the cylinder of an engine when the intake valve is open.

In the liquid state, matter usually has a more defined form, that is, it is more confined than in the gaseous state. In general, liquid **cannot** be compressed, that is, pressure applied to a specific volume will not change that volume, just transmit the pressure.

Increasing the temperature of a liquid however, will cause expansion and cooling will usually cause contraction. This change of volume is not near as great in liquids as it is with a gas. Each substance has as a specific rate of expansion and contraction which gives rise to a coefficient peculiar to each individual substance. Water is the exception to the above generality. Water, as it cools, contracts until it reaches 4°C. As the temperature continues to decrease the water expands and ice (the solid state of H_2O), becomes less compact and lighter than the surrounding H_2O. For this reason ice floats in water, whereas solid iron settles to the bottom if put into a container of liquid iron.

Unlike a gas, which expands to fill all available space, a liquid flows until all connected surfaces are about level. Any diffusion from the surface of a liquid in a gaseous form is dependent on the boiling point of that liquid.

The solid state of matter is the most dense of the three, that is, the molecules are moving much slower and on shorter paths than in liquid or gas. Solids also do not expand or contract with pressure, but they do contract and expand with temperature changes.

Force and Movement

Another area that needs to be mentioned is force and movement, because all movement is dependent on one or more forces. When you apply force to an object, then that object moves (if the force is great enough). An object at rest will remain at rest until enough force is applied to overcome the natural inertia (created by its mass) of that object. The rate of movement is called the velocity of the object. The rate at which the movement changes is called the acceleration, which can be increasing or decreasing.

An opposing force to all movement is one called friction, which is the resistance to motion of any two or more surfaces in contact with each other. The rougher that the touching surfaces are, then the greater the friction between the objects. This friction can be reduced if one or more of the objects is rolling instead of sliding. By the same token, if a cushion of air or liquid is maintained between the two surfaces, the friction will be the least that can be obtained.

A form of force that we are all familiar with is called gravity. This force exists between any two bodies of the universe, dependent on their respective masses and the distance between them. This force of gravity keeps all things on Earth including the envelope of air around us. If it were not for the great force of gravity on Earth, rockets to outer space would be a simple matter. The great thrust of power when a rocket is launched, is necessary to have the rocket break free from the Earth's pull of gravity. The pressure created by the mass of air around the earth and the force of gravity is approximately 100 kPa at sea level. It is the force created by gravity that gives us the measurement that we call weight (found by multiplying the mass of an object by the acceleration due to gravity being applied to it).

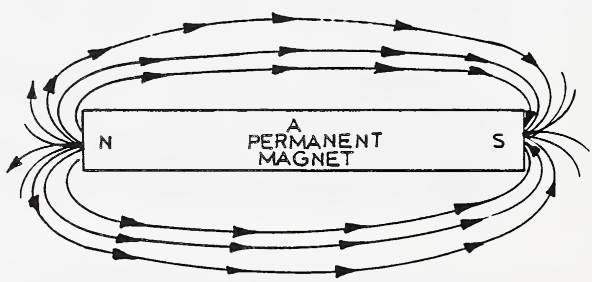
Electrical Terms

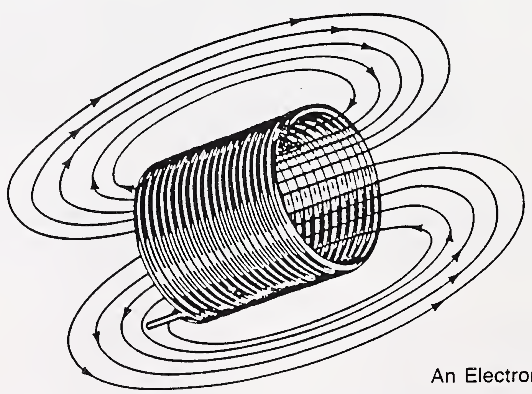
Voltage is the force or pressure which causes current to flow. If voltage is increased in an electrical circuit, more current will flow.

Current is the flow of electrons in a circuit. The amount of current flowing in a circuit is measured in ampers using an ammeter.

Magnets, Magnetism, and Current

We are all familiar with toy magnets that attract various metal objects. These toy magnets are known as permanent magnets. There are two types of magnets, one is natural while the second is artificial (man made). Natural magnets are those made of magnetite, an iron ore, which was originally found in Asia Minor near a settlement called Magnesia. This ore has a very strong attractive force called magnetism. A magnet has two poles, known commonly as the north and south poles. This pole distinction is due to the arrangement of the protons and electrons in the molecules which make up the magnetic material. A permanent magnet has a concentration of free electrons at the north end and a deficiency of electrons at the south end. An artificial magnet is commonly called an electro magnet, this only acts as a magnet as long as the electric current is flowing through a coil of wire.





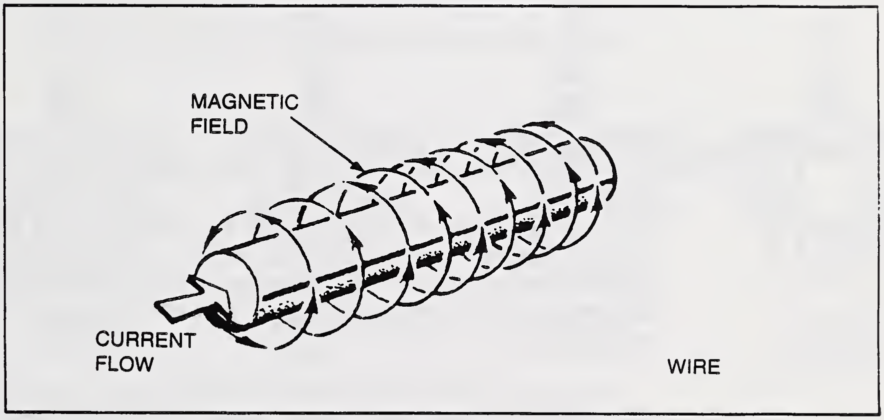
An Electromagnet

Some basic rules concerning the production of a current with the use of magnets are as follows:

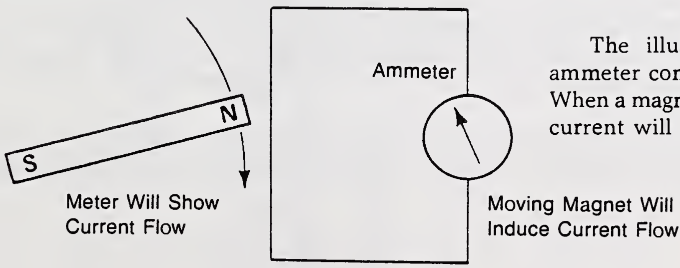
(a) Current is produced when a magnet is moved past a wire which is part of a complete circuit.

(b) A magnet moved past a coil made up of several turns of wire will produce a much stronger current flow because the current induced in each turn of wire will add to the total output.

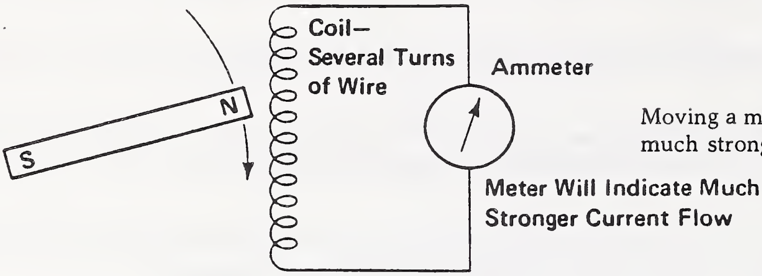
(c) Current flowing through a wire causes a magnetic field around the wire. The more current flowing through the wire, the stronger the magnetic field.



(d) If the wire is formed into a coil, the magnetic field of each turn of wire adds to the field next to it, thus producing a stronger magnet. The more turns of wire added, the stronger the magnetic field becomes.



The illustration to the left shows an ammeter connected to a closed loop of wire. When a magnet is moved rapidly past the wire, current will flow through the wire.



Moving a magnet past a coil of wire produces much stronger current flow.

Magnets are a very important part of all small engines as will be seen in the next lesson.

Appling Principles of Combustion

Let us apply the principles learned so far to an intenral combustion engine. The fuel is mixed with the air by the carburetor. In fact, to each tablespoon of gasoline approximately eighteen litres of air are mixed. The fuel-air mixture (a mist) enters the engine due to a partial vacuum which is created when the piston travels downward in the cylinder. Here the mist changes to a gas or vapor.

At the end of the intake process, the intake valve closes and the gases in the cylinder are trapped. As the piston moved upward toward top dead center (TDC), the gas is compressed.

Compressing the gas pushes the molecultes closer together. This will cause the gas to burn more violently when ignited. The heat created due to the violent burning causes the gas in the cylinder to expand. This expanding gas exerts great pressure on the piston causing it to move down in the cylinder. This is the point at which the chemical energy of the burning fuel is changed to mechanical energy.

Combustion, in terms of internal combustion engines, means that an air-fuel mixture is drawn into the cylinder, is changed to a gas by heat, is compressed by the piston, and is ignited to provide heat which expands the gases in the cylinder. These expanding gases in the cylinder push the piston which transmits force to the crankshaft.

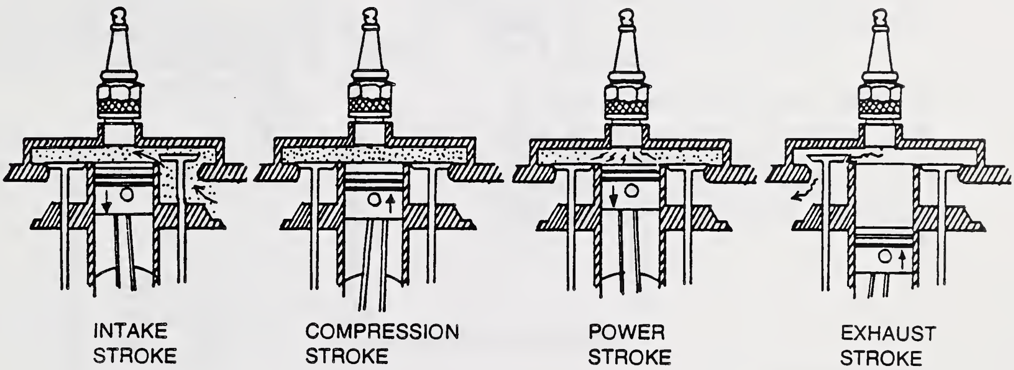
Note that the mixture does not explode in the engine. Allowing the mixture to explode will produce a ''knocking'' condition. This condition will cause excess heat and can damage the piston.

FOUR-STOKE CYCLE THEORY

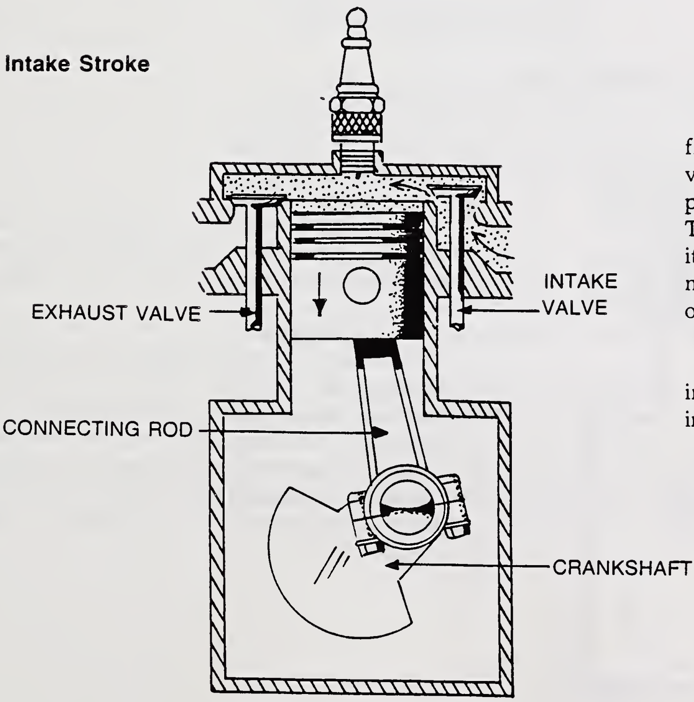
To complete one stroke, the piston has to travel from either top dead center (TDC) to bottom dead center (BDC) or from BDC to TDC.

Cycle refers to the completion of four strokes of the piston before it repeats a stroke.

Therefore, a four-stroke cycle engine is one that requires four strokes of the piston to complete one cycle. The following diagram shows the strokes of a four-stroke cycle engine.



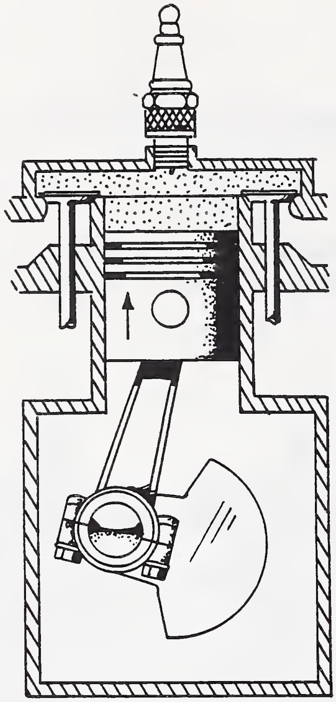
Intake Stroke



During the intake stroke the piston moves from TDC to BDC. This causes a partial vacuum inside the cylinder. Atmospheric pressure rushes toward the partial vacuum. The air rushes through the carburetor where it is mixed with gasoline. This gasoline air mixture then enters the cylinder through the open intake valve.

The intake valve closes near the end of the intake stroke trapping the air-fuel mixture inside. The pistion is now at BDC.

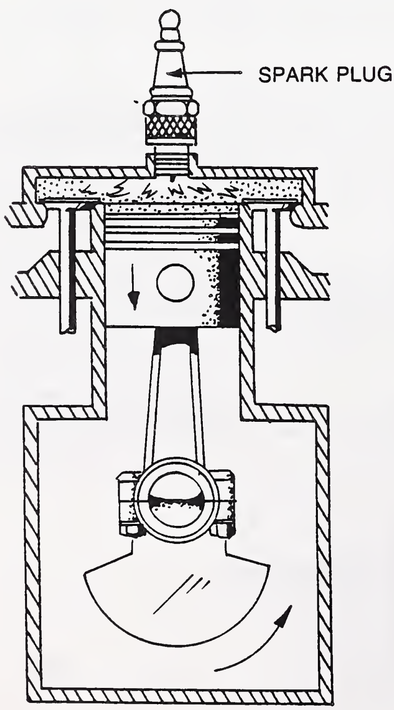
Compression Stroke



The compression stroke is the second stroke in the cycle. The rotating crankshaft moves the piston from BDC to TDC. Both valves remain closed during this stroke, thus there is no way that the air-fuel mixture inside the cylinder can escape. As the piston moves upward toward TDC, the volume of the cylinder decreases and the air-fuel mixture is compressed more and more until TDC is reached.

Compressing the air-fuel mixture produces more pressure when the mixture is burned.

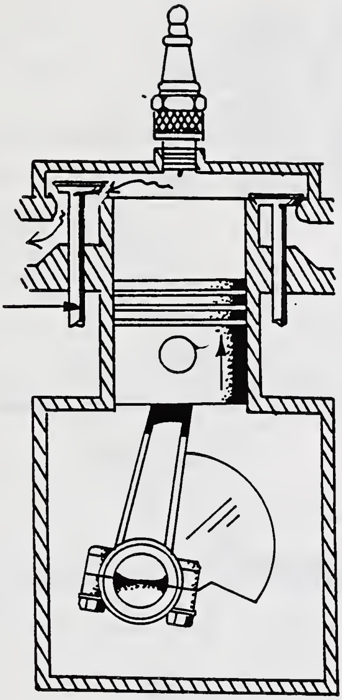
Power Stroke



Just before the piston reaches TDC on the compression stroke, a spark jumps across the spark plug gap and the power stroke begins.

The spark ignites the very volatile fuel-air mixture and the gases expand. As the gases expand, the pressure within the cylinder increases greatly. The piston being the only part inside the cylinder that will move when pressure is exerted (both values are closed), moves down toward BDC. The force on the piston is transmitted to the crankshaft via the connecting rod.

Exhaust Stroke



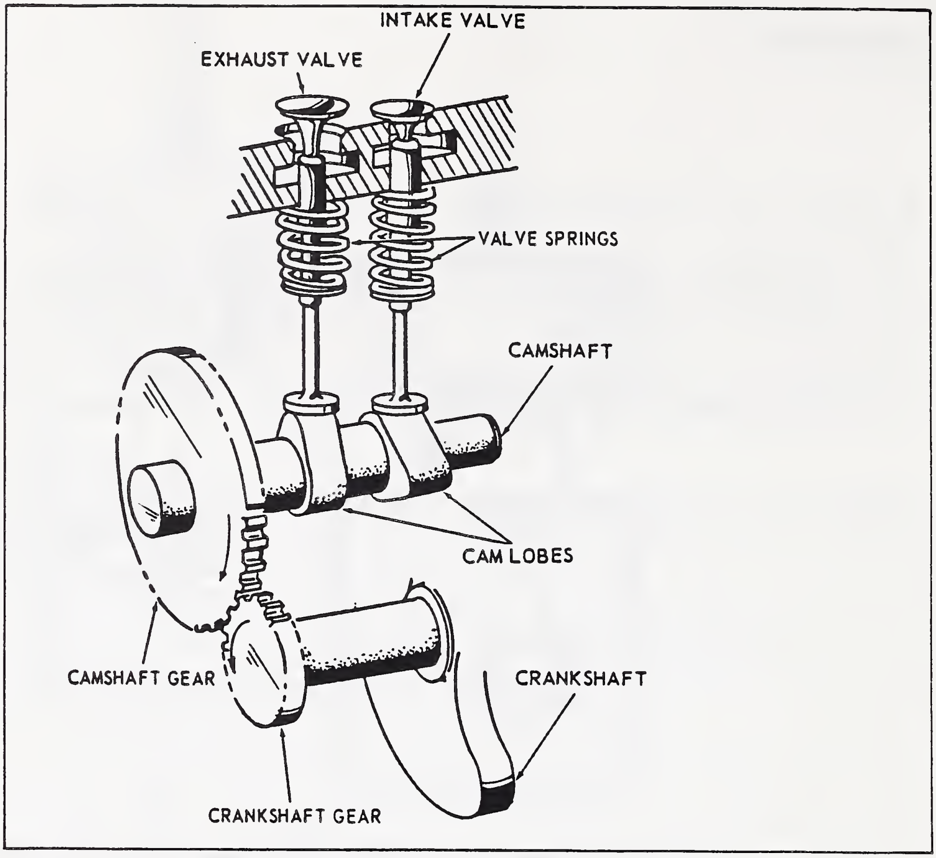
Near BDC of the power stroke the rotating camshaft causes the exhaust valve to open. The piston now moves upward from BDC to TDC pushing the burned gases through the open exhaust valve and out the muffler.

Just before the piston reaches TDC, the exhaust valve closes and the intake valve opens. Thus another cycle begins. The sequence; intake, compression, power and exhaust repeats itself as long as the engine is running.

In all engines the crankshaft can be considered as the backbone of the system. When the engine is operating, the crankshaft, which is driven by the power stroke, rotates continuously while the engine is running. The power strokes are intermittent but the counter balance weights and the flywheel give sufficient momentum to the crankshaft to keep it running between power strokes.

The flywheel on small single-cylinder engines is usually quite heavy because there is only one piston delivering power once every four strokes. On many rotary type lawnmowers the blade of the mower aids the flywheel in keeping the rotation of the crankshaft smooth. Without the blade attached these engines will run roughly.

The next most important shaft, but only in four cycle engines is the camshaft, which is driven by the crankshaft. The ration between these two shafts is usually 2:1 (two to one) so that the camshaft only turns once during two complete revolutions of the crankshaft. It is this camshaft which opens and closes the exhaust and intake valves at the correct times. In larger engines it also controls the oil pump, distributor, and in turn the ignition timing.



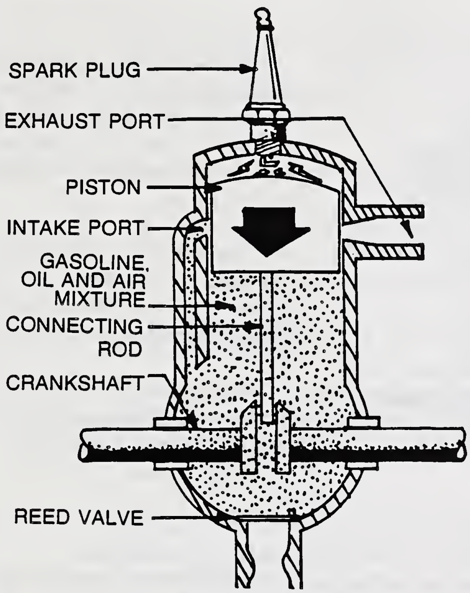
Camshaft and Valve Operation (Four-Stroke-Cycle)

TWO-STROKE CYCLE THEORY

A two-stroke cycle engine is designed to complete all of the actions (a cycle) decribed for the four-stroke cycle engine in two strokes of the piston. This means that a two-stroke cycle engine completes a cycle each time the crankshaft completes one revolution.

Stroke One is known as **'Power-exhaust-intake'**. As the piston is moving downward, away from the cylinder head, all three actions take place. We will trace these actions in the following illustrations.

Power

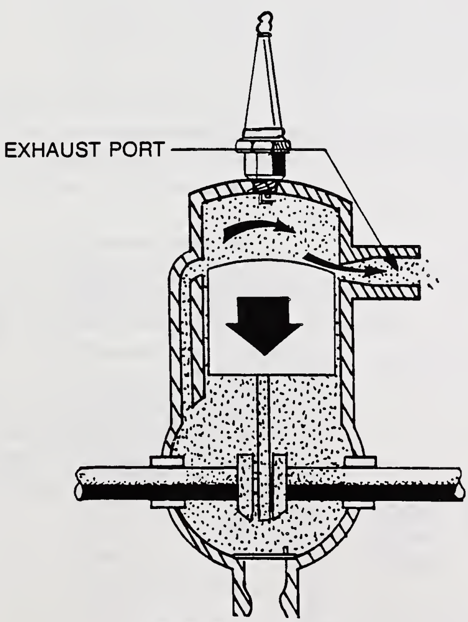


STOKE I — POWER

Pressure of the burning gases pushes the piston down toward BDC. This event provides power to turn the crankshaft. (The fuel was ignited about the time the piston reached TDC.)

Before the piston reaches BDC, it uncovers the exhaust and intake ports.

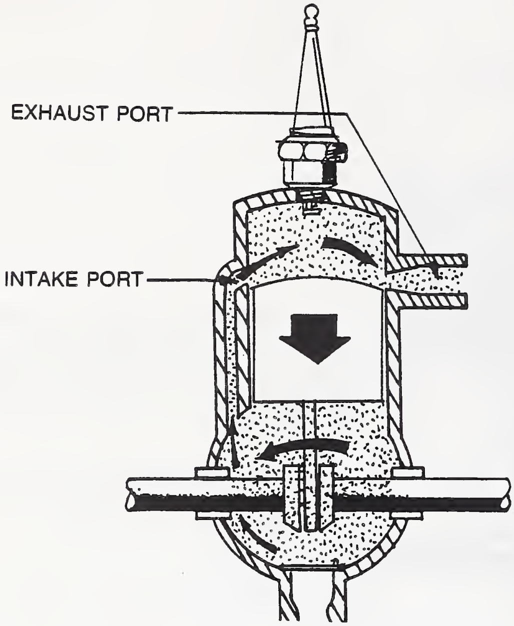
Exhaust



STROKE I — EXHAUST

The exhaust port is uncovered first. The hot gases, which are still under pressure from combustion, escape through the opening and then out the muffler.

Intake



STROKE I — INTAKE

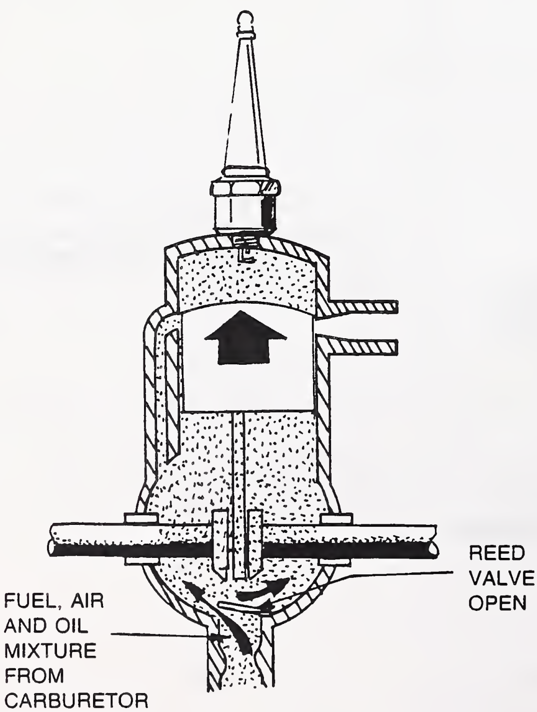
The piston, still on its way down, uncovers the intake port next. A fresh fuel-air-oil mixture is forced into the combustion chamber (cylinder) from the crankcase where the mixture was under slight pressure. The piston reaches BDC.

Pressure in the crankcase is the result of the downward movement of the piston. This pressure causes the reed valve to close allowing pressure to build up.

The incoming mixture also helps to drive out the remaining exhaust gases. (This is known as cross-scavenging).

Stroke two is known as **compression.** The piston now begins its upward motion.

Compression



STROKE II — COMPRESSION

The piston moves upward covering both the intake and exhaust ports. The now trapped fuel-air-oil mixture inside the cylinder is being compressed into a smaller and smaller space.

As the piston moves upward, a partial vacuum is created in the crankcase. Atmospheric pressure on the outside opens the reed valve and forces a fresh mixture of fuel-air-oil from the carburetor into the crankcase.

Just before the piston reaches TDC, a spark from the spark plug ignites the mixture, and it starts to burn. This begins another power stroke and the cycle repeats itself.

The major differences between the four-stroke cycle engine is as follows:

1. The number of power strokes per crankshaft revolution.

2. The method of getting the fuel mixture into the combustion chamber and the burned gases out.

3. The method of lubricating the internal moving parts.

   (a) Since the two-stroke cycle engine uses the crankcase for storing a fresh mixture of fuel-air-oil for the next stroke, the crankcase cannot be used as an oil sump. Instead lubrication is supplied by the oil that is mixed with the fuel.

4. The number of working parts as well as the physical size of the engine.

As can be seen from the previous sections, both the two-stroke cycle engine and the four-stroke cycle engine operate on the same basic principles. The two-stroke cycle is the simplest of the two systems requiring far less parts and is therefore the easiest to work with for tuneups and repairs.

The one function that is totally different in the four-stroke cycle system, is that of lubrication. Without lubrication an engine will last only a very short time. In small engines this can be considered as the most critical area. In the two-stroke cycle engines lubrication is performed by the oil that is mixed with the fuel, but in the four-stroke cycle engine oil is contained separately in the lower part of the crankcase.

Some engines use an oil pump to circulate the lubrication (especially in larger engines) or the other method is by dippers or a splash system. Some engines use combinations of the above. Usually the lubrication system used depends a lot on the application in which the engine is going to be used. It is very rare to find a pump system on any single cylinder engine but as more cylinders are added, the usage of a pump becomes more important as parts get further away from the oil pump and hence much harder to lubricate.

Here are some aspects to consider about two and four cycle engines. Two engines with identical power and one cylinder design would compare as follows.

Characteristics	**Four-Stroke Cycle**	**Two-Stroke Cycle**
Number of moving parts	9	3
Number of crankshaft rotations between power strokes	2	1
Running temperature	cooler	hotter
General size	larger	smaller
Mass (weight)	heavier	lighter
Acceleration	slower	much faster
Initial cost	more	less
Maintenance cost	more	less
Power to weight ratio	less	more
Operating sound	much quieter	very loud
Efficiency (fuel)	more	less

Complete the following questions and send them in for correction.

1. What are the three states of matter?

   (a) ____________________

   (b) ____________________

   (c) ____________________

2. In which state of matter is material the least dense?

   ____

3. An opposing force to all movement is called ____________________.

4. What is the **most efficient** way to reduce friction?

   ____

5. Give the meaning of these two abbreviations.

   (a) TDC ____________________

   (b) BDC ____________________

6. The part of a two-stroke cycle or four-stroke cycle engine that contains the crankshaft is called the ____________________.

7. What is a stroke?

   ____

8. What shaft does a four-stroke cycle engine have that is not used in the two-stroke cycle engine?

   ____

9. What replaces the reed valve in a four-stroke cycle engine?

   ____

10. What two actions take place on the strokes when the piston is moving downward in a four stroke cycle engine?

(a) ____________________

(b) ____________________

11. What two actions take place on the two strokes when the piston is moving upward in a four stroke cycle engine?

(a) ____________________

(b) ____________________

12. What do cam lobes do?

____

____

13. Explain how the two-stroke cycle engine is lubricated.

____

____

____

14. What are two advantages of a two-stroke cycle engine?

(a) ____________________

(b) ____________________

15. What are two advantages of a four-stroke cycle engine?

(a) ____________________

(b) ____________________

16. In a two-stroke cycle, how many revolutions are made by the crankshaft of the engine in one cycle?

____

17. In a two-stroke cycle, what is the name given to the stroke that moves the piston downward in the cylinder?

____

18. In a two-stroke cycle, what is the name given to the stroke that moves the piston upward in the cylinder?

____

19. List the four strokes of the four-stroke cycle engine in their correct operational order.

(a) _______________

(b) _______________

(c) _______________

(d) _______________

20. For proper combustion to occur, fuel must explode in the cylinder. (True or False)

____

21. Compressing the air-fuel mixture creates more pressure when it is burned. (True or False)

____

22. During the power stroke of a four-stroke engine, one valve is open. (True or False)

____

23. The crankshaft receives power only during one of the four strokes of the four-stroke cycle engine. (True or False)

____

24. Lawnmower engines may tend to run roughly when operated without the blade attached. (True or False)

____

25. The purpose of a small engine's flywheel is to smooth out the reciprocating power strokes. (True or False)

____

26. The air-fuel-oil mixture is first compressed in the crankcase of a two-stroke cycle engine. (True or False)

____

27. The reed valves prevent the air-fuel-mixture from escaping from the crankcase of a two-stroke cycle engine? (True or False)

____

END OF LESSON 2

LESSON RECORD FORM

5037 Small Engines

Revised 91/09

FOR STUDENT USE ONLY	
Date Lesson Submitted ________	(If label is missing or incorrect)
Time Spent on Lesson ________	File Number ________
	Lesson Number ________

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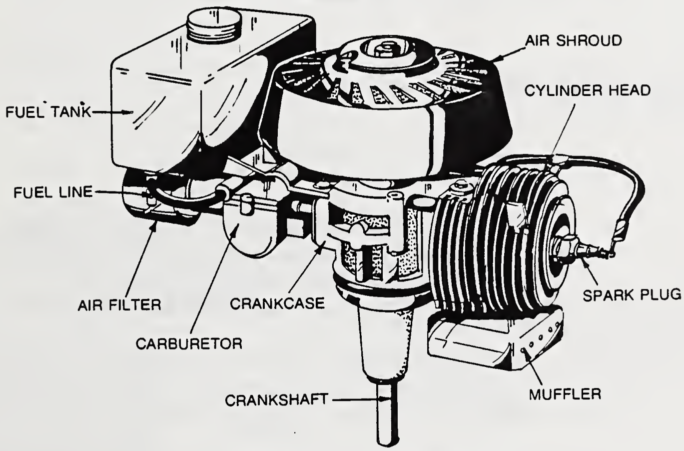
St. Serv. 9-91

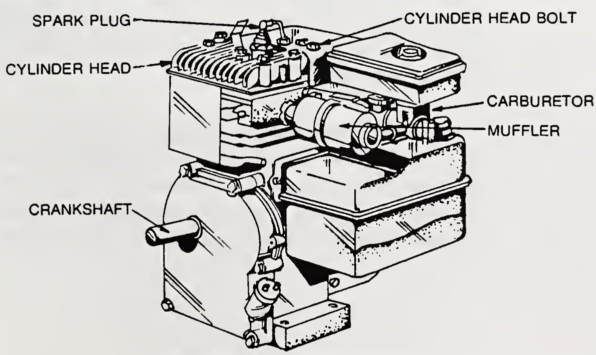
ENGINE SYSTEMS

INTRODUCTION

Small engines are usually of two types; the vertical crankshaft type or the horizontal crankshaft type. This classification refers to the position in which the crankshaft lies in the engine crankcase. Most lawnmowers for example, use a vertical shaft engine.



VERTICAL CRANKSHAFT ENGINE



HORIZONTAL CRANKSHAFT ENGINE

Small engines are made up of five basic systems. These systems are:

1. Fuel
2. Ignition
3. Lubrication
4. Cooling
5. Exhaust

These systems all work together to convert the chemical energy of fuel and air into mechanical energy. Each system has its own function and must be properly timed to the other systems in order for an efficient conversion of chemical to mechanical energy to take place.

FUEL SYSTEM

The purpose of the fuel system is to provide the proper air-fuel mixture to the combustion chamber. The fuel-air mixture must be of sufficient quantity and of the proper proportion to meet the demands of the engine under all conditions. Proper adjustments of the carburetor and an adequate supply of clean fresh fuel will help ensure the proper operation of this system.

FUEL SYSTEM ÇOMPONENTS

1. The Fuel

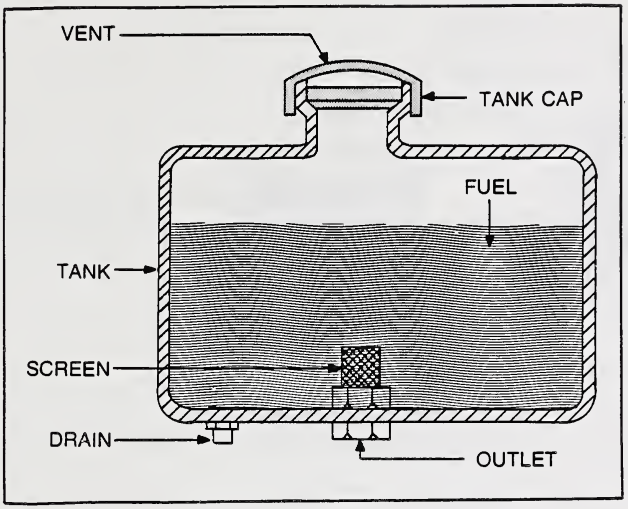
Most manufacturers recommend the use of **regular grade** or no lead gasoline. Producers of gasoline blend the fuel to meet climatic conditions in the area in which it is sold. Oil companies blend thier gasoline so volatility is low in the summer. If you use summer gasoline in the winter, you may have trouble starting your engine.

In the winter, volatility is increased for easy starting. If you use winter gasoline in the summer, you will have more loss from evaporation. Gasoline should be purchased in small quantities to assure freshness.

Remember, a two stroke cycle engine requires a gasoline-oil mixture. Always follow the manufacturer's recommended oil type and mixture ratio. Too much oil will cause poor combustion and the formation of gum, varnishes, and carbon deposits. Inadequate lubrication and increased wear on moving parts may result if too little oil is used. Be sure that the oil is mixed thoroughly in a separate container before adding any fuel to the fuel tank.

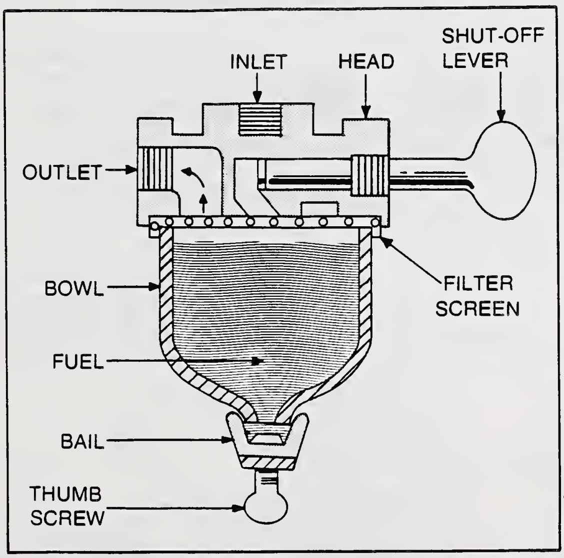
Never store fuel in a tightly closed room. Use an approved container and store in a cool, dry place. Gasoline in small containers and small fuel tanks tends to deteriate with age (anywhere from 1 to 4 months). Deterioration will result in gums and varnishes forming which will interfere with proper engine operation. **Never refuel a "running" engine**, as a fire could result when a spark or heated parts come in contact with the fuel.

2. Fuel Tank



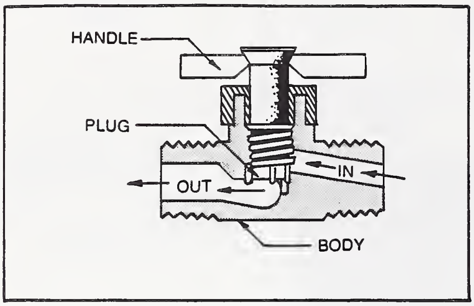
The fuel tank is the storage compartment for the fuel. It comes in nearly every conceivable shape and size to fit the engine which it will supply.

3. Fuel Filters



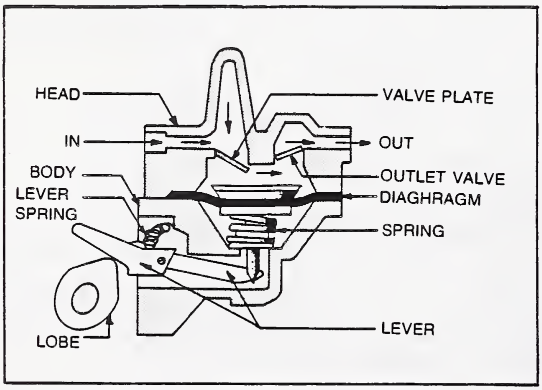
The fuel filter could be part of the fuel tank or mounted in the line between the fuel tank and the carburetor. Its purpose is to remove foreign particles from the fuel. It must be kept clean with regular servicing.

4. Shut-off Valve



Some fuel systems use a shut-off valve to close off the line from the fuel tank to the rest of the system.

5. Fuel Pump



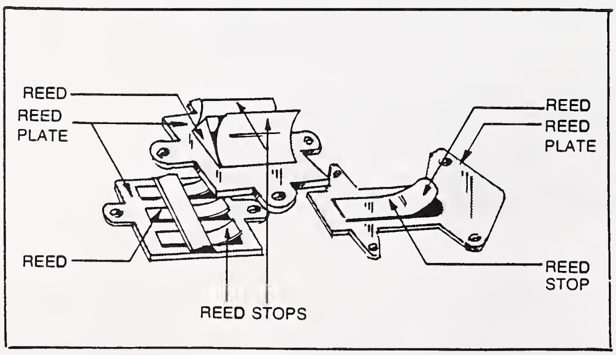
There are three types of fuel supply systems on small engines: the gravity-feed system, the suction-feed system and the pressure-feed system.

The gravity-feed system has the fuel tank mounted above the carburetor and fuel flows by gravity to the carburetor.

The suction-feed system relies on suction from the low pressure area in the carburetor to draw fuel from the tank.

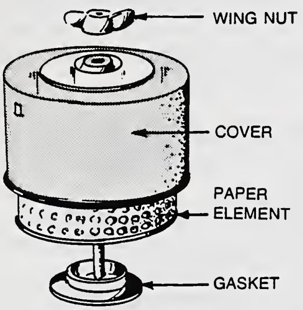
The pressure-feed system relies on a pump installed between the tank and the carburetor to supply the fuel pressure to the carburetor. These pumps are mechanically operated.

6. Reed Valves



Reed valves are used only on two cycle engines. They act as check valves allowing the air-fuel-oil mixture to enter the crankcase only during the compression position of the stroke.

7. Air Cleaner

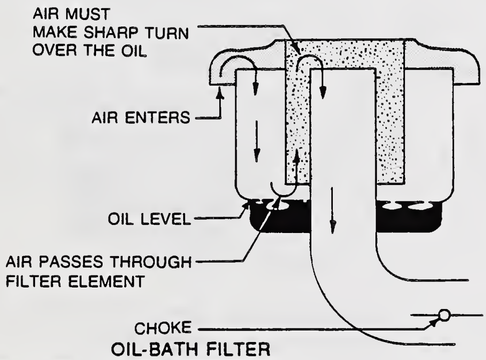


DRY PAPER FILTER

The air cleaner is a unit designed to remove foreign particles from the air before they enter the carburetor.

There are three types of air cleaner systems: the dry paper filter, oil-foam filter and the oil-bath filter.

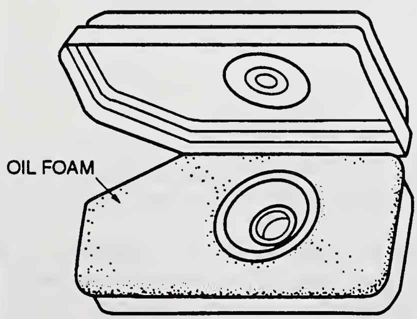
The dry paper filter uses porous paper to allow air flow through the filter but sill collects dirt and foreign matter.



OIL-BATH FILTER

Oil-bath air cleaners are used on engines that must operate under very dirty conditions. This type of filter is capable of removing large quantities of foreign matter. The incoming air is forced to make a sharp turn just above the oil. The dirt and foreign matter does not make the bend but travels straight into the oil and sticks there. The air then travels through the filtering element.

Polyurethene Foam Type Filter



POLYURETHANE FOAM FILTER

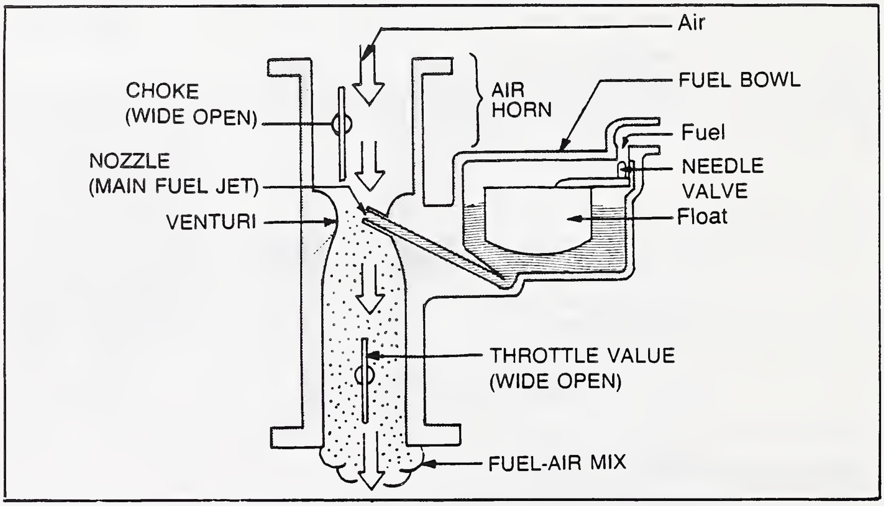
The oil foam filter utilizes a polyurethane foam element which is lightly oiled. The air passing through the foam is filtered due to the dirt sticking to the oil. This is the most common type of filter found on lawn mowers.

8. Carburetor

There are many different types of carburetors in use for small engines but they all perform the same two basic functions: to mix fuel and air in the correct ratio and to vaporize the liquid fuel. This is complicated by the fact that the carburetor must provide the correct air-fuel mixture through a wide range of engine speeds, varying loads, and varying temperatures. This means that the ratio of the mixture must change continuously during engine operation.

Good combustion requires a correct fuel-air mixture. A mixture that has too much fuel is called a **rich mixture**. An engine running on this type of mixture will emit black smoke from the exhaust and will also lack power. The result of an engine operating with a rich mixture will be a rapid build up of carbon on the piston, valves, and head along with rapid wear due to the dilution of the oil on the cylinder walls.

A **lean mixture** does not have enough fuel for the air entering the engine. Operating an engine with a fuel mixture that is too lean will cause a loss in power, surging, and overheating which can lead to a lubrication breakdown on the cylinder walls.



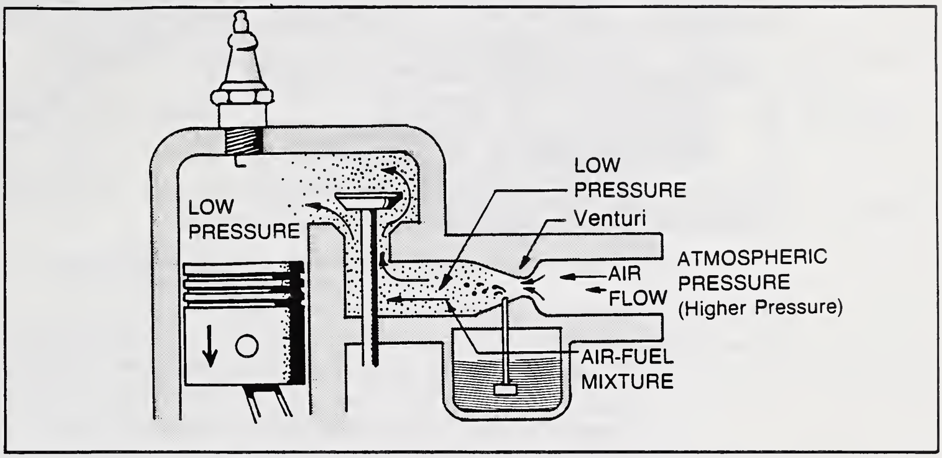
A simplified carburetor showing the major parts.

PRINCIPLES OF CARBURETION

The following is a generalization of the principles of carburetion as it pertains to all carburetors. Specific types of carburetors will be discussed later in this lesson.

In the two-stroke cycle engine air begins to travel through the carburetor air horn due to the suction created in the crankcase by the upward stroke of the piston. In the four-stroke cycle engine, the suction is created inside the combustion chamber from the downward stroke of the piston. The higher atmospheric pressure outside of the engine pushes air into the carburetor.

As the air rushes in it passes through a restriction known as the **venturi.** As the air flow moves through the narrowed part of the venturi it increases in speed creating an area of low pressure. Since the fuel in the fuel bowl or in the line is at higher pressure (atmospheric pressure), the fuel is drawn out of the nozzle into the air stream where it vaporizes and mixes with the air.



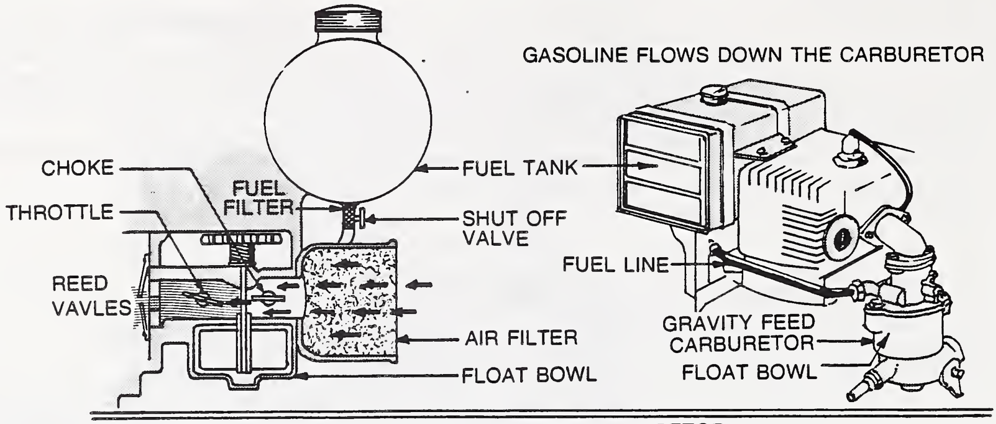
In order for the carburetor to operate properly, the carburetor must be divided into four basic systems of operation.

(i) the supply system
(ii) the high speed system
(iii) the idle speed system
(iv) the choke system

1. The Supply System

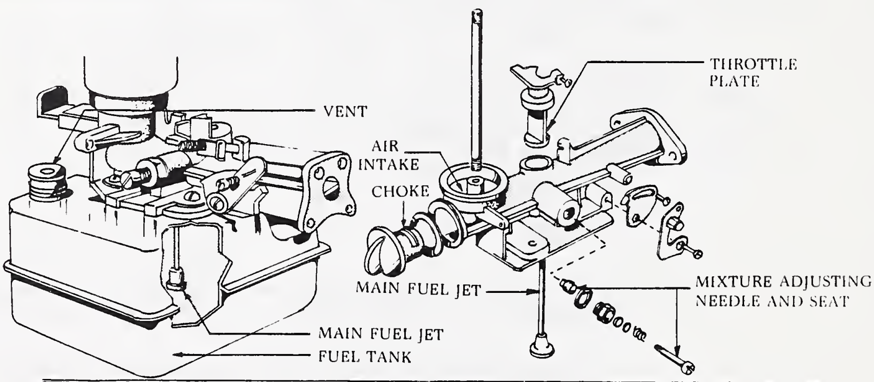
As mentioned eariler in this course, carburetors used on small engines are classified according to the method by which they draw fuel from the tank.

Gravity feed carburetors have a fuel tank mounted above the carburetor. The gasoline flows because of gravity into the fuel bowl. The level of fuel in the bowl is controlled by a float and needle valve. As the fuel enters the bowl, the float rises, closing the needle valve and thus stopping the flow of fuel from the tank.



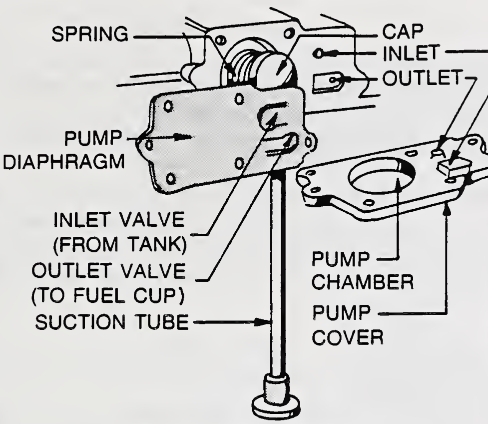
GRAVITY FEED CARBURETOR

Another type of carburetor is the suction feed type. This type of carburetor is attached to the top of the fuel tank. The main fuel jet hangs down into the fuel tank, therefore no fuel bowl is needed.

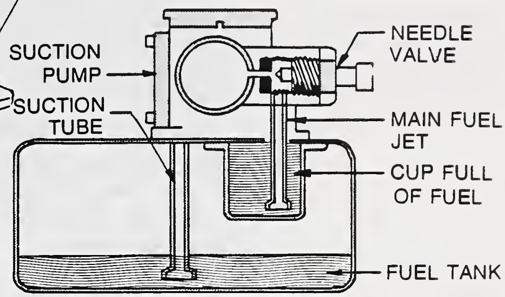


SUCTION FEED CARBURETOR EXPLODED VIEW OF SUCTION FEED CARBURETOR

The pump type of system is used on engines that must be able to operate in any position (e.g. chain saws). One type of carburetor in this system has a built-in fuel pump that keeps a small cup of fuel full at all times. This type of carburetor is known as a diaphragm carburetor. Other carburetors may have a separate pump which is usually operated mechanically.



Parts of a diaphragm carburetor fuel pump.

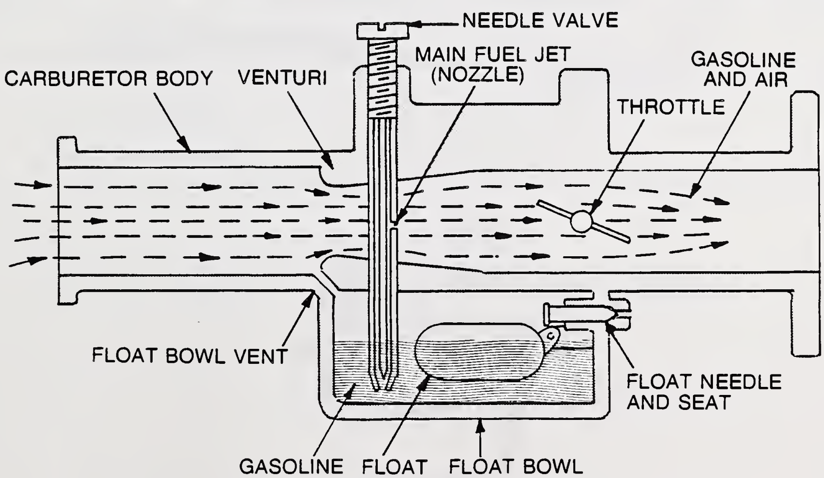


Cutaway of a diaphragm carburetor with built-in fuel pump

2. The High Speed System

The high speed system regulates the fuel mixture during normal speed and load operations. It is probably the most important since fuel economy, engine power, engine temperature, and engine life are all dependent on the correct mixture.

The amount of fuel drawn into the air-stream is determined by the amount of air flowing through the venturi. As the throttle is opened, the air flow will increase and the pressure in the venturi (by the main fuel jet) will become even lower, thus increasing the fuel flow into the airstream. The proportion of air to fuel remains the same over the range of speeds.

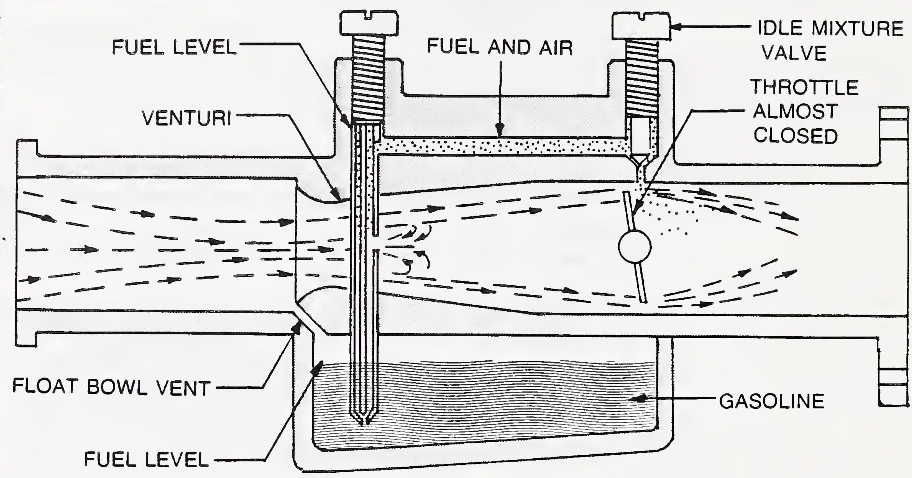


Cutaway of carburetor showing the high speed system in use

3. The Idle System

The idle system supplies the correct air-fuel mixture to the engine when the engine is at idle and low speeds. At low speeds, air flow through the venturi is too slow to create the low-pressure area required to draw the fuel into the venturi. A separate idle circuit is connected to the area just behind the almost closed throttle.

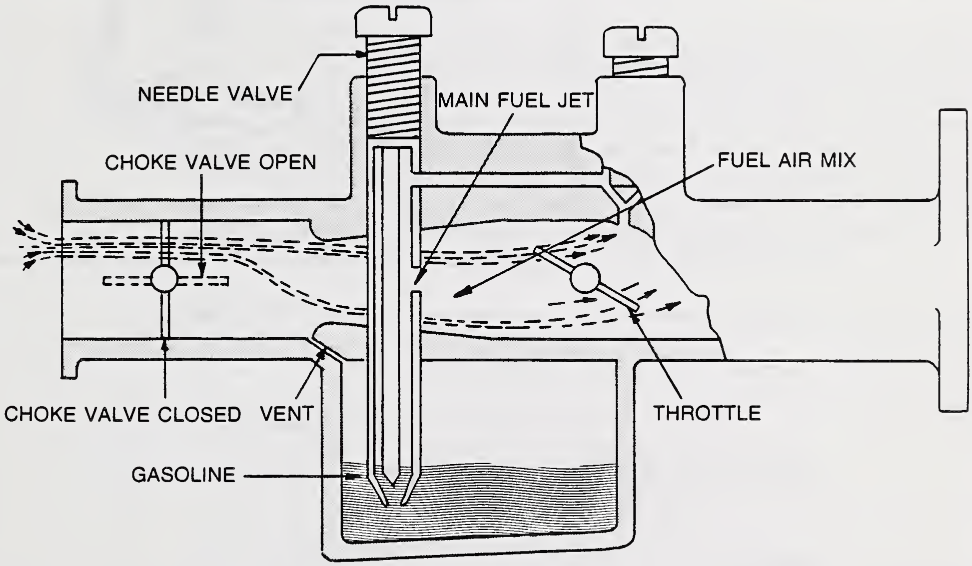
To allow the engine to run at a slow idle speed, fuel and air are drawn to the carburetor throat due to a small low pressure area behind the throttle plate. The air and fuel flow through a small passageway to a jet known as the idle mixture screw. From there the mixture of fuel and air enter the throat of the carburetor just behind the throttle plate.



THE IDLE SPEED SYSTEM

4. The Choke System

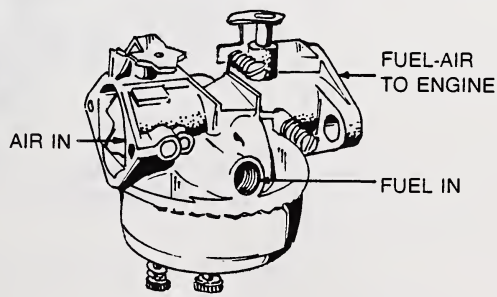
A cold engine needs a rich mixture in order to start and run for the first few minutes. A choke valve or butterfly is placed just before the venturi. Its purpose is to reduce the amount of air entering the carburetor and to cause more fuel to be drained in from the main fuel jet. The choke valve has a hole or notch in it to let some air through it when fully closed. When the choke is closed, fuel and air are still drawn through the idle circuit.



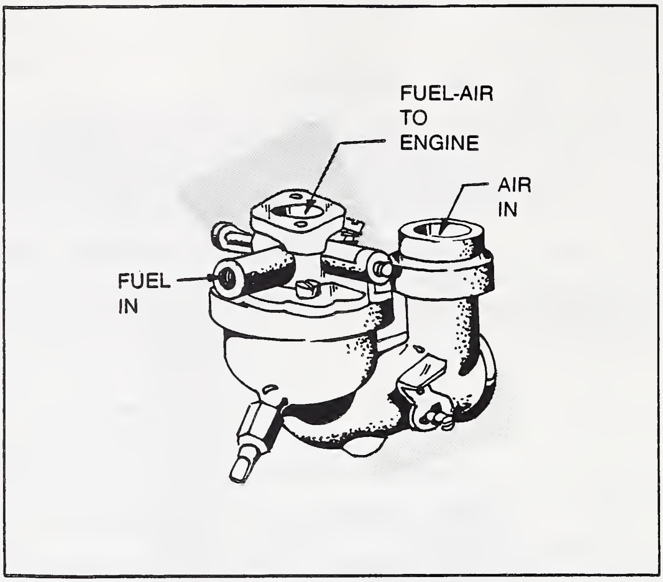
The Choke System

Carburetors can be mounted to an engine in three ways:

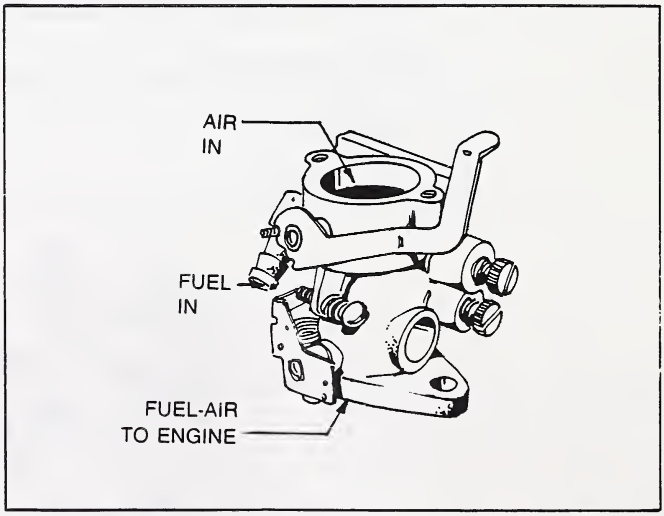
(a) Up Draft
(b) Side Draft
(c) Down Draft



SIDE DRAFT



UP DRAFT



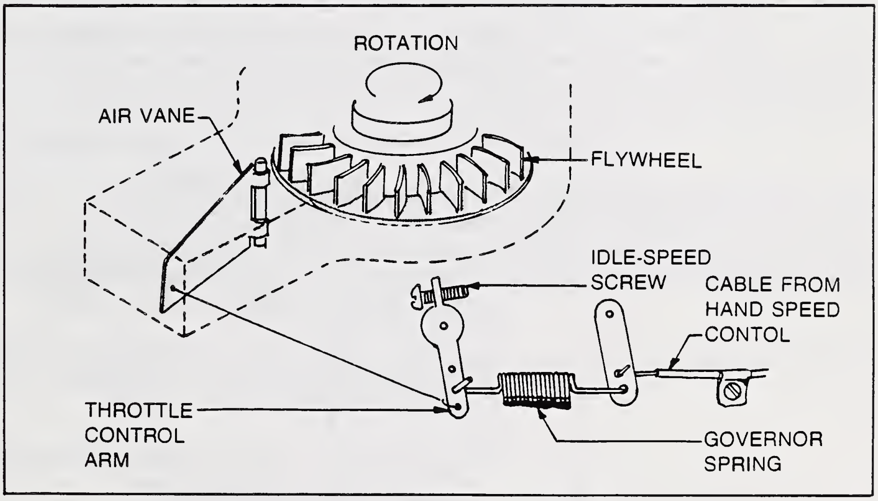
DOWN DRAFT

5. Governors

Engine speed can be controlled by either the operator's manual control of the throttle or automatically by the governor. Small engines that are used to power a constant load use a governor to maintain constant speed as the load changes. Two types of governor systems are used on small engines; air vane governors and mechanical governors.

(a) Air Vane Governors

Air vane governors are the most widely used type of governor for small engines because they are quite simple and inexpensive. This system uses an air vane, located under the shrouding near the flywheel, to sense engine speed using the amount of air flow created by the fins of the rotating flywheel. An increase in engine speed, increases the force of the air flow from the flywheel. This force pushes against the air vane which is connected by a wire linkage to the throttle control arm. The pull against the governor spring closes the throttle and reduces the engine speed. Engine speed is determined by a balance between the pull of the air and the pull on the governor spring by the hand control.



When an operator increases engine speed, the governor spring will pull harder on the throttle control arm thus causing the throttle to open wider. The result will be an increase in engine speed until the air flow from the flywheel against the air vane increases to equal the pull of the governor spring.

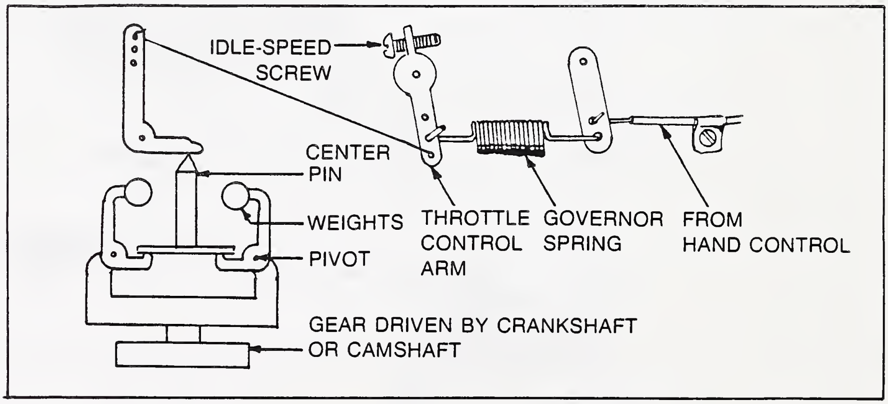
When the engine speed decreases (due to an increased load on the engine), the force of the air flow against the air vane also decreases. The governor spring will pull harder on the throttle control arm and open the throttle wider. Again, engine speed will increase until the force of the air flow against the air vane equals the pull of the governor spring.

(b) Mechanical Governors

Mechanical governors are more precise and dependable than air vane governors but add more weight to the engine and are more expensive.

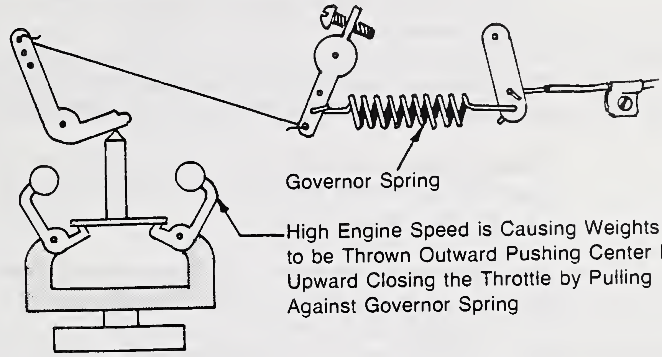
Most mechanical governors rely on the principle called centrifugal force in obtaining control. This principle simply means that as the speed of a rotating object is increased there is a greater centrifugal force developed which is outward from the centre. As a rotating object decreases in speed the centrifugal force decreases.

Engine speed is determined by the amount of centrifugal force exerted on rotating weights located inside the crankcase.



Engine Not in Operation

As engine speed increases, the weights are thrown outward by centrifugal force, the centre pin is lifted upward, and the throttle is pulled closed (engine speed decreases). See the illustration on the next page.



Engine in Operation

When a load causes the engine speed to decrease, centrifugal force on the weights will decrease and the force exerted on the center pin will be reduced. The center pin will move downward allowing the governor spring to open the throttle and increase the engine speed. The governor will again exert pull against the governor spring as the engine speed recovers and engine speed will be maintained.

These two actions reoccur rapidly so that, in effect, the throttle plate is held at the position which effectively maintains a constant engine speed. If the load on the engine is increased or decreased, the change in engine speed is reflected in the governor action, and the throttle plate is repositioned to provide the same engine speed under the new load conditions.

Remember there are many types of governors, but their basic operation is the same as described in this lesson.

IGNITION SYSTEM

The function of the ignition circuit is to create a spark and ignite the compressed fuel-air mixture at the precise moment. This requires very high voltage to cause an electric current to jump the gap between the spark plug electrodes.

The ignition system consists of the following components:

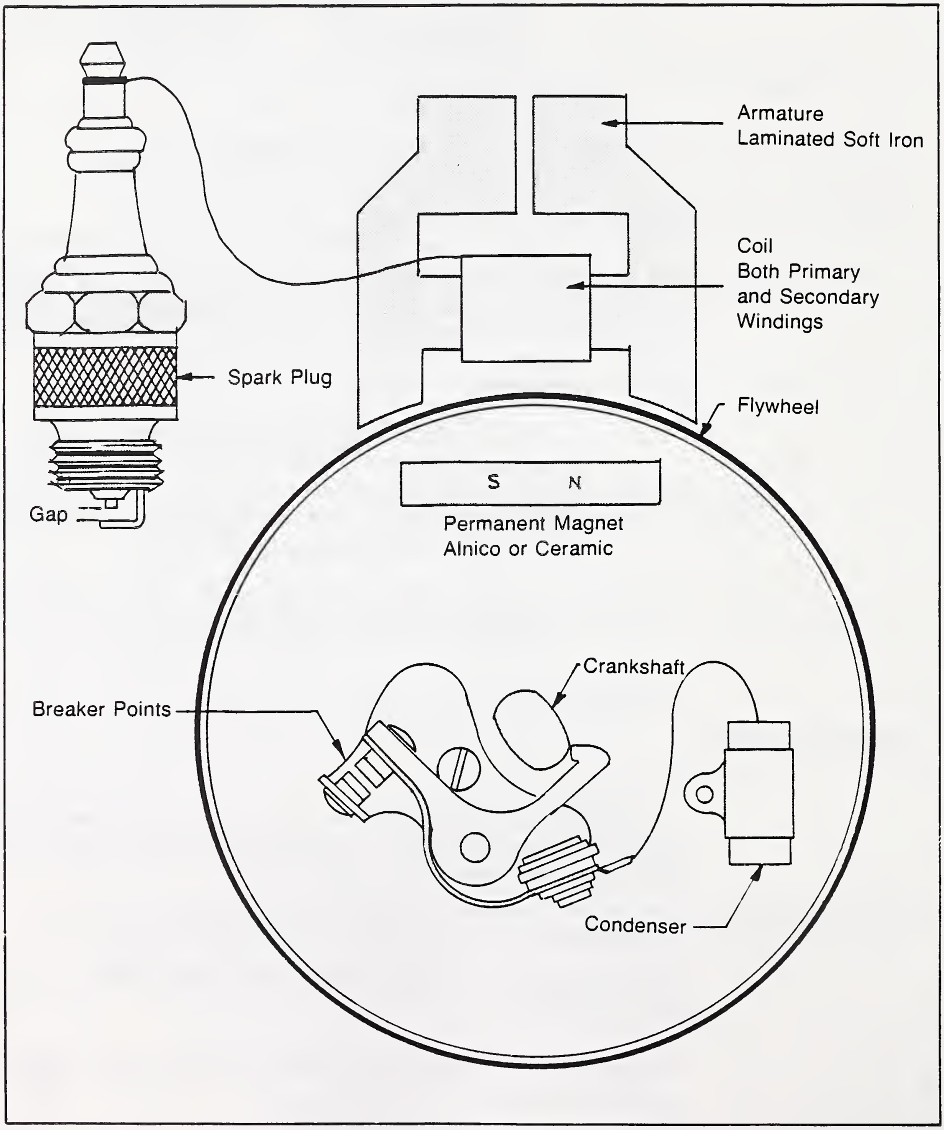
Flywheel Magnet — causes current to flow in the primary coil winding as it moves rapidly past the coil assembly.

Armature-Coil Assembly — consists of a laminated steel armature and the primary and secondary winding.

Breaker Points — a switching device operated by the crankshaft. The points close before the flywheel magnet passes the coil completing the primary winding circuit. The points open to cause power to be transferred to the secondary circuit and cause a much higher voltage to fire the plug.

Condenser — a safety device for the points. It is connected across the breaker points to help reduce arcing of the points thus increasing their life.

Spark Plug — the firing device which ignites the fuel-air mixture. A spark plug creates a gap in the electrical circuit until the required voltage (6 000 volts at idle and 10 000 volts under load) jumps the gap.



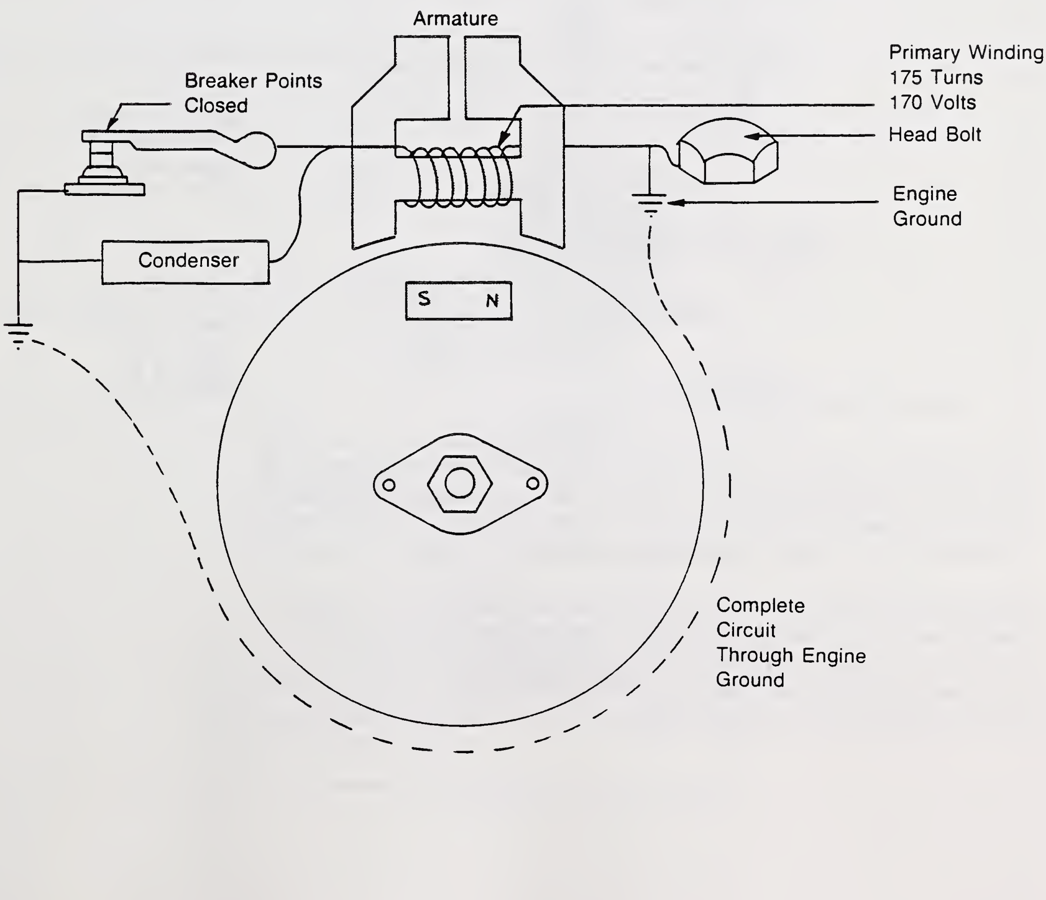
Small Engine Magneto Ignition Components

IGNITION SYSTEM COMPONENTS

The ignition system consists of two circuits. The **primary circuit** consists of the flywheel magnet, breaker points, condenser, and the primary coil winding (made up of relatively few turns of heavy wire). The **secondary circuit** has a coil with many turns of lighter wire which are wound around the outside of the primary winding. The secondary circuit also includes the spark plug.

1. Primary Circuit

As mentioned earlier the primary circuit consists of the flywheel magnet, breaker points, condenser, and the primary winding. The primary circuit is often called the low-voltage circuit. The primary winding consists of about 200 turns of coated copper wire wound on the laminated armature. One end of this wire is connected to the armature by one of the mounting bolts (which also connects it to the engine ground). The other end of the primary winding is connected to the breaker points. The condenser is connected in parallel with the breaker points to prevent arcing. There is a complete circuit from the engine ground through the primary winding, through the breaker points, to the engine ground when the breaker points are closed.



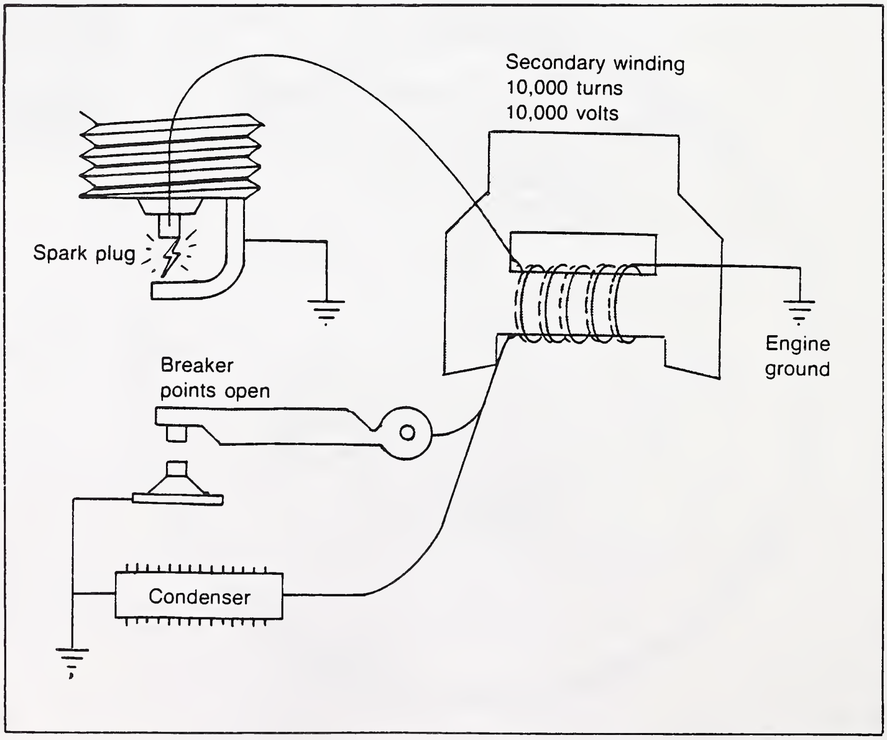
When the piston nears TDC of the compression stroke, the breaker points close making a complete circuit. The rapidly passing flywheel magnet brings primary current to maximum. This produces a strong concentrated magnetic field around the primary winding. Just a few degrees before TDC (the number of degrees are determined by the manufacturer) the breaker points open, stopping all current flow in the primary circuit. The magnetic field suddenly collapses. A small amount of current is absorbed by the condenser in order to prevent the breaker points from arcing as they open.

An incorrect setting of the breaker points would affect the time when the points would open and thus greatly affecting engine timing.

2. Secondary Circuit

The secondary winding, consisting of approximately 10 000 turns of very fine wire, which is wrapped around the primary winding. One end of the secondary winding is connected to ground along with one end of the primary winding while the other end is connected to the spark plug.

The magnetic field surrounding the primary winding also surrounds the secondary winding. When the points open, the primary magnetic field collapses across the secondary winding. This collapsing magnetic field (which is just like a rapidly moving magnet moving past the secondary winding) tries to induce current flow in the secondary winding. However, a complete circuit does not exist because of the spark plug gap, so current cannot flow. The voltage builds up until it is great enough to jump across the spark plug gap (usually about 10 000 to 12 000 volts). The spark only occurs when the points are open.

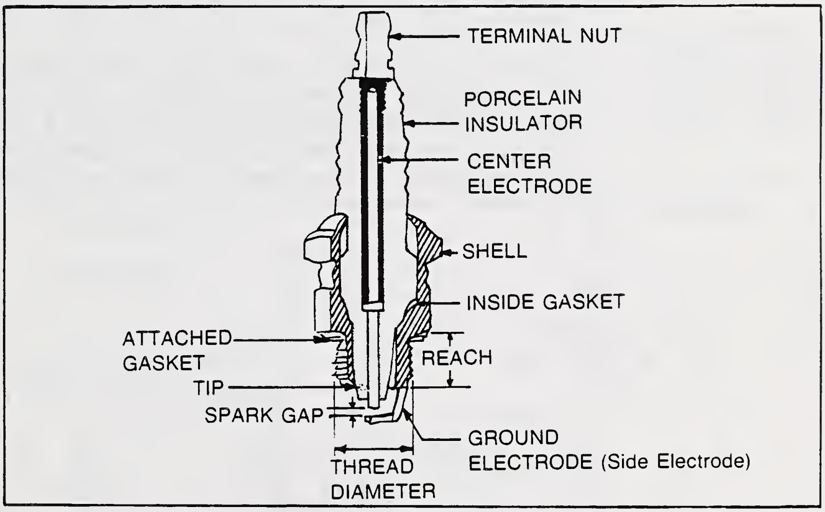


The following sequence summarizes the events involved in creating a spark for igniting the fuel-air mixture.

(a) The breaker points close, completing the primary circuit.
(b) The flywheel magnet passes the windings, producing current flow in the primary winding.
(c) The current flow in the primary winding produces a strong magnetic field which surrounds both windings.
(d) The breaker points open, causing the magnetic field to collapse across the secondary winding.
(e) Several thousand volts are produced in the secondary winding which fire the spark plug.

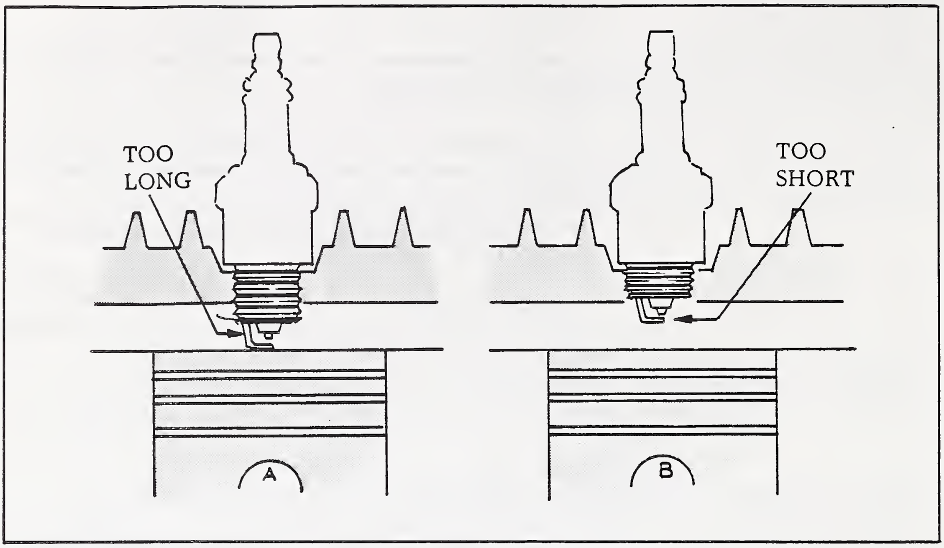
(a) Spark Plug

The spark plug is the part of the ignition system which ignites the fuel mixture. It must operate under severe and varying temperature conditions and is a critical part of small engine operation.



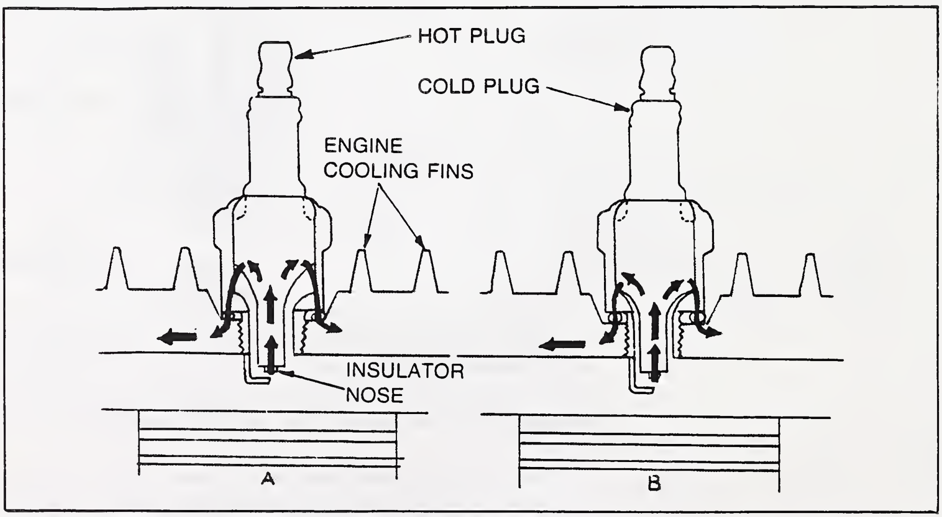
The center electrode is insulated from the shell by a ceramic insulator such as porcelain. The side electrode is fastened to the spark plug shell which is in turn grounded on the cylinder head. The air gap between the electrodes on the spark plug ranges from 0.5 to 1.00 mm depending on usage and specifications.

The reach of a spark plug is the distance between the gasket seat and the bottom of the spark plug shell (see diagram above). Reach determines how far the electrodes protrude into the combustion chamber. If the reach is too short, the electrodes will have difficulty iginiting the mixture. Too long a reach may cause the piston to strike the electrodes on its upward stroke. The exposed threads will collect deposits and the plug will be hard to remove.



Spark plugs are also made in several heat ranges so that there is a suitable plug for any given engine for different operating conditions. For example, at continuous high-speed operation a very cold plug is desirable, while slower operation requires a hot plug.

It must be remembered that the interior of a combustion chamber can be exposed to heat in the area of 2 500°C at the beginning of the power stroke, when operating at full throttle. NOTE: The melting point of iron is only 1 400°C, so this excess heat must be dissipated as fast as possible, to prevent the engine from seizing up. The heat that is thus absorbed by the plug is conducted into the cylinder head as shown in the diagram below.



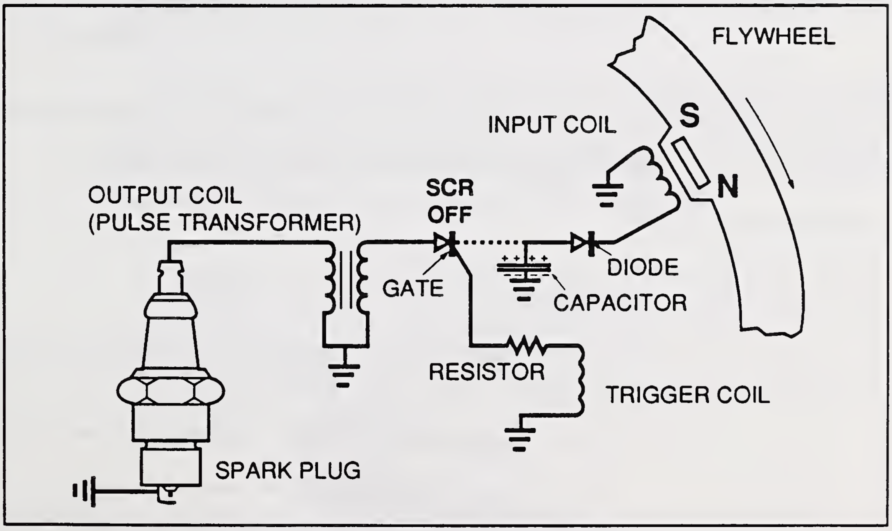
Spark plugs are available by heat types. (a) Hot type has a long insulator nose. Heat must travel farther to reach the cooling fins. It stays hotter than (b) the cold type, with a shorter insulator nose.

The longer the heat takes to dissipate from a plug the hotter this plug will operate at. In this way the nose of the plug is kept within an operating temperature so that the electrodes are not melted or eroded by the hot flame, nor the insulator damaged by excessive temperatures. The hottest part of the plug is the tip of the nose. Heat flows up through the plug as shown by the arrows. As is seen, the longer the plug is the hotter it will operate because the heat flow decreases as the length increases. Therefore, the longer a plug is the hotter it is, so a cold plug will be fairly short. Thus the cold plug is recommended when the car is to be driven on an open throttle most of the time, to help dissipate the heat faster. Slow speed operation with these plugs will foul them up but not sufficient to hinder their operation as long as there are period of high speed operation to burn them clean periodically. The opposite is true about hot plugs, which if used in an engine at high speed for a considerable length of time will be ruined.

The spark plug gasket (usually a copper type washer) is a very important factor in conducting the heat from the plug to the cylinder head. If not torqued to a proper pressure it can seriously obstruct the flow of the heat. So if the plug is too tight or too loose, the heat damage which results will greatly reduce the life and efficiency of the plug operation. NOTE: remember two plugs of the same size can have different heat ranges dependent upon the thickness and type of material used which compensates for lengths.

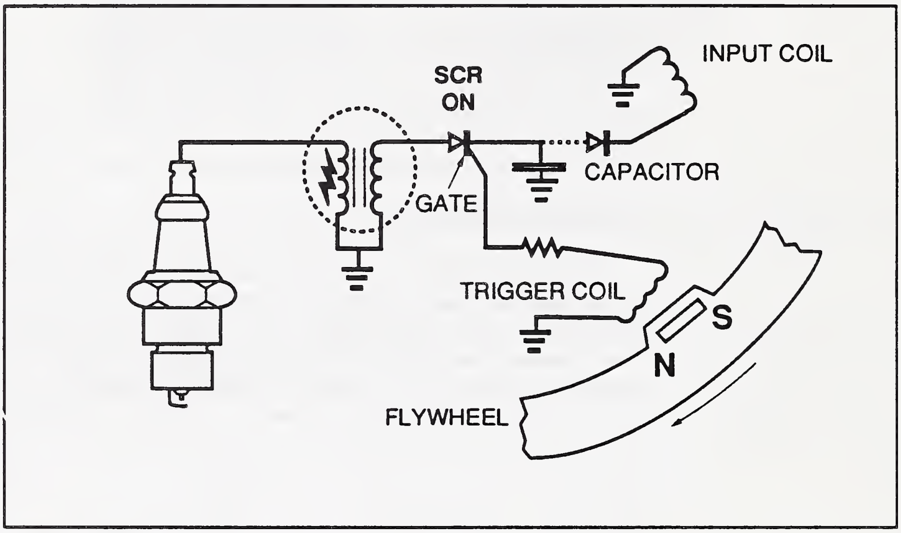
ELECTRONIC IGNITION

Solid-state or electronic ignition is becoming increasingly popular on small gas engines. With this type of ignition system the breaker points have been replaced with an electronic switch called an SCR. The SCR is triggered or turned on by a small coil. The only moving part in this system is the flywheel which does not make moving contact with other parts. With no moving parts to wear, periodic adjustments are not required.



As the flywheel magnet passes the input coil alternating current is induced in the coil. The diode allows the current to flow in one direction only. The current flow charges the capacitor. At this point, the SCR remains off. This is illustrated above.

After the flywheel magnet passes the input coil it passes the trigger coil which produces enough voltage to trigger the SCR. A resistor protects the SCR from excessive current flow. When the SCR is triggered on it opens a path for the capacitor, which was left holding a charge, to discharge through the primary winding of the pulse transformer to the engine ground. This sudden pulse of current through the primary of the pulse transformer produces a magnetic field which induces a very high voltage in the secondary winding and the spark plug fires. The interaction of the primary and secondary winding in the pulse transformer is similar to that of a conventional coil. This is illustrated below.



Spark timing is determined by the position of the trigger coil.

LUBRICATION SYSTEM

1. Purpose

The basic function of a lubrication system is to reduce friction between moving surfaces. However, the lubricating oil must perform other jobs as well.

(a) It lubricates moving parts to minimize wear and to reduce power loss from friction.

(b) It helps cool the engine by removing heat from the moving engine parts.

(c) Oil absorbs shocks between bearings and other engine parts, thus reducing engine noise and prolonging engine life.

(d) Oil forms a seal between piston rings and cylinder walls.

(e) It acts as a cleaning agent and protects parts from rust and corrosion.

2. Properties of Oil

To perform the previously mentioned functions satisfactorily, oil must have certain characteristics or properties. Oil must resist oxidation, reduce carbon formation, prevent corrosion, prevent rust, operate at extreme pressures, and prevent excessive foaming. It must pour and flow at low temperatures, and must have and maintain proper viscosity at very high and low temperatures. Finally, oil must act as a good cleaning agent.

No oil by itself has these properties. Oil manufacturers, therefore, put a number of additives into the oil during the manufacturing process.

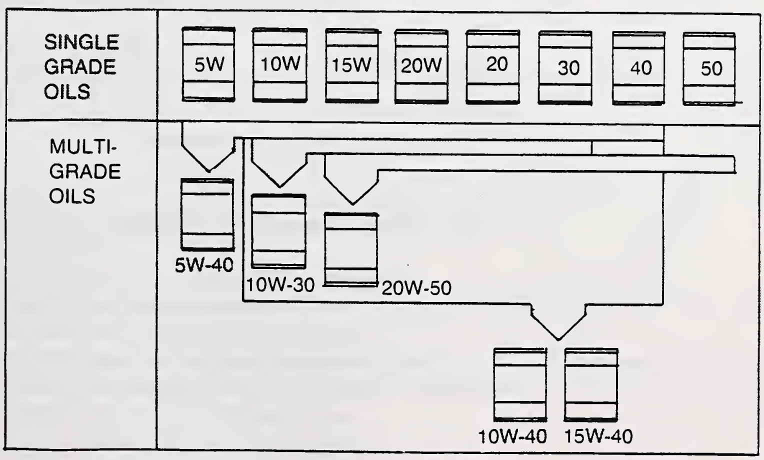
(a) Viscosity

Viscosity is the term used to describe how fluid an oil is (its resistance to flow). This is probably one of the most important properties of lubricating oil. Temperature influences viscosity. Increasing the temperature makes the oil thin out or, in other words, reduces viscosity. Decreasing the temperature causes the oil to thicken or increase in viscosity.

The Society of Automotive Engineers (SAE) rates oil viscosity for winter and for other than winter. Winter-grade oils are tested at – 18°C. Three winter-grades are presently available: SAE5W, SAE10W, and SAE20W. The "**W**" indicates winter grade oil. Oils designated for other than winter are tested at 99°C. These grades are SAE20, SAE30, SAE40, and SAE50. Notice that these grades do not contain the "**W**".

Viscosity index is a number indicating how much the viscosity changes with temperature. We have indicated previously that when oil is cold, it is thicker and runs more slowly than when it is hot. This is a major reason why an engine is harder to sart when it is cold.

Oil chemists have developed compounds that tend to hold oil viscosity constant, whether cold or hot. This makes cold starting easier and does not thin out oil too much when hot. These oils are termed **multi-grade**. A multi-grade oil can replace many single-viscosity oils. For example, an oil rated SAE10W-30 is the same as SAE10W when cold and SAE30W when hot.



(b) Service Ratings of Oil

Lubricating oil is rated in another way. It can be rated by its service designation (AP1 Rating). This designation rates the oil according to the type of service for which it is best suited. There are seven service ratings for gasoline engine lubricating oils: SA, SB, SC, SD, SE, SF, and SG.

(i) **SA Oil** — Oil for utility gasoline and diesel engines operating under very mild conditions. Contains no additives.

(ii) **SB Oil** — This oil took the place of service SA. Designed for service in gasoline engines operated under very mild conditions. Only minimal protection by additives required.

(iii) **SC Oil** — This oil superseded service SB. This oil was designed for use in gasoline engines in the 1964-67 models of cars and trucks. This oil provide control of engine deposits, wear, rust, and corrosion.

(iv) **SD Oil** — Superseded service SC. For service typical of gasoline engines in cars and trucks begining in 1968 models. Provided more protection from engine deposits, wear, rust, and corrosion than SC oils.

(v) **SE Oil** — Superseded service SD. For service typical of gasoline engines in cars and trucks beginning with some 1971 models. Provided even more protection against oxidation, high temperature engine deposits, and rust and corrosion than SC or SD oils.

(vi) **SF Oil** — An improved oil which replaced service SE for gasoline engines beginning with the 1980 models. This service provides increased oxidation stability and improved anti-wear performance. These oils also provide protection against engine deposits, rust, and corrosion. Oils meeting this service requirements may be used where service SE, SD, or SC are recommended.

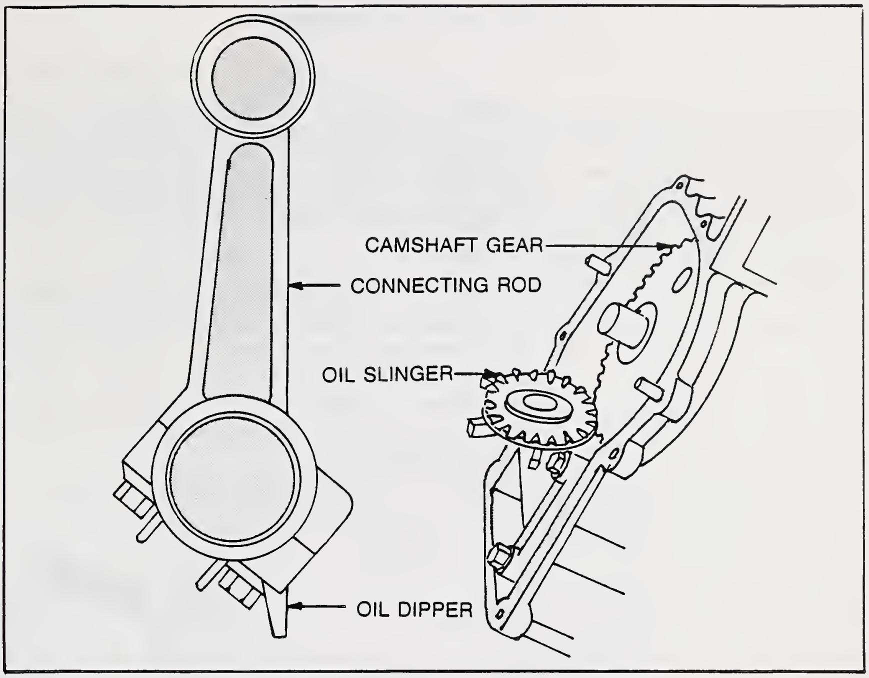
(vii) **SG Oil** – Still yet another rating has been added with improved perfomance against viscosity breakdown and greater fuel economy.

In selecting an engine oil, you have to consider both the viscosity and the service classification. Your operator's manual recommends the type of oil you should use for the conditions under which you are operating the engine.

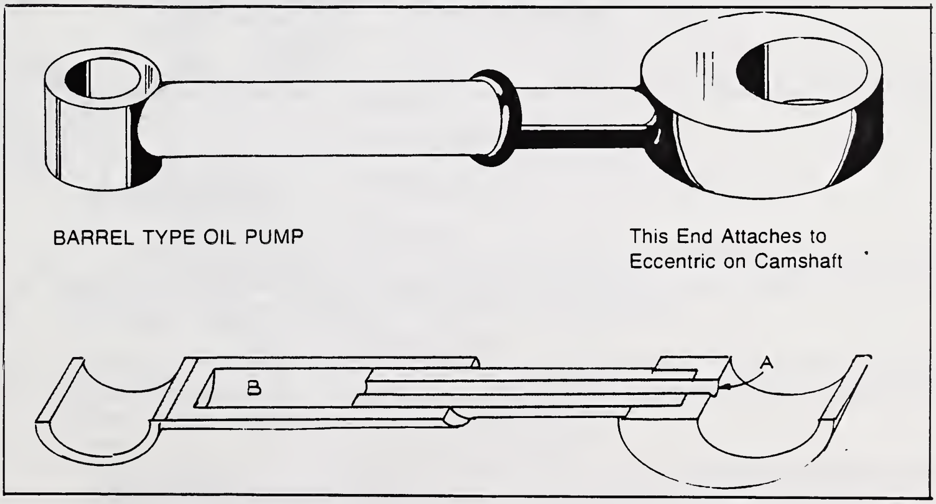
3. Types of Lubrication Systems

(a) Four-Stroke Cycle Engines

(i) Splash System — In the splash system, oil is splashed from the lower part of the crankcase so that all points within the block are constantly sprayed with oil. Some engines use a dipper attached to the connecting rod which splashes the oil as the connecting rod moves. Other engines use an oil slinger driven by the camshaft to accomplish this task. As the slinger rotates the small gearlike parts on the slinger throw oil throughout the inside of the engine. The splash system is most common for power lawn mowers, roto-tillers and other similar applications.



(ii) Pump System — Small engines use various styles of oil pumps. The pumps usually direct the oil to the connecting rod and main bearings by passages in the discharge tube. The oil which is thrown off the connecting rod and crankshaft lubricate the other parts of the engine.

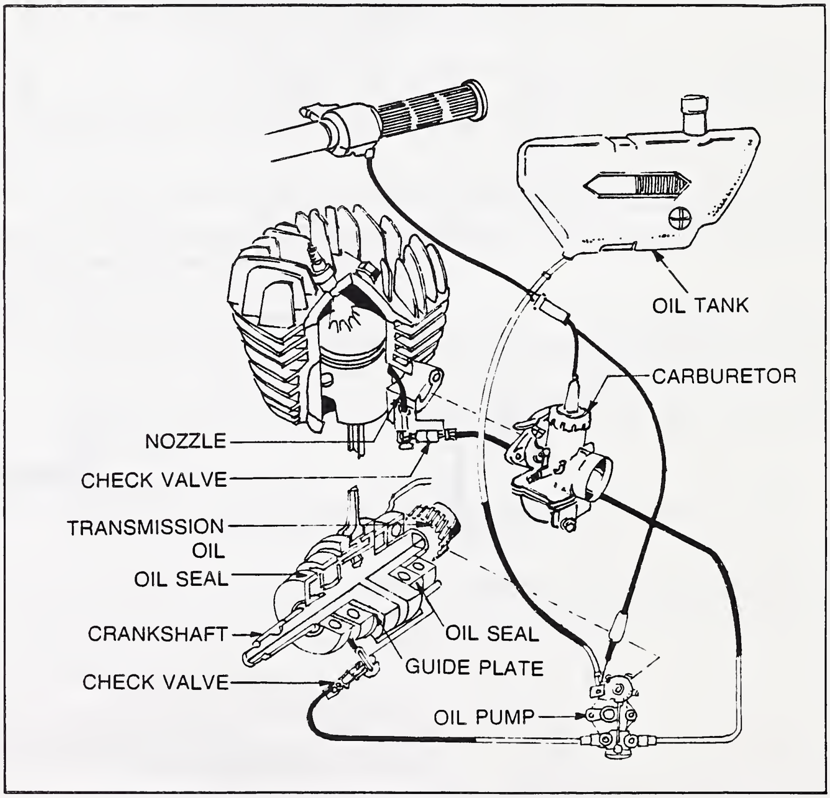


As the pump extends, oil enters the pump at point A and flows into chamber B. When the pump is contracted, oil is pushed out of chamber B, up the passage and through point A, and through a passage in the camshaft.

(b) Two-Stroke Cycle Engines

Since the air-fuel mixture passes through the crankcase it is not possible to maintain a reservoir of oil in the crankcase. To provide lubrication of two cycle engine parts, the oil must be mixed with the fuel. When the air-oil-fuel mixture enters the crankcase, the fuel evaporates and passes on to the engine (cylinder) as an air-fuel mixture. The air-fuel mixture carries some oil along with it and is burned. However, enough oil is left behind to keep the moving engine parts coated with oil.

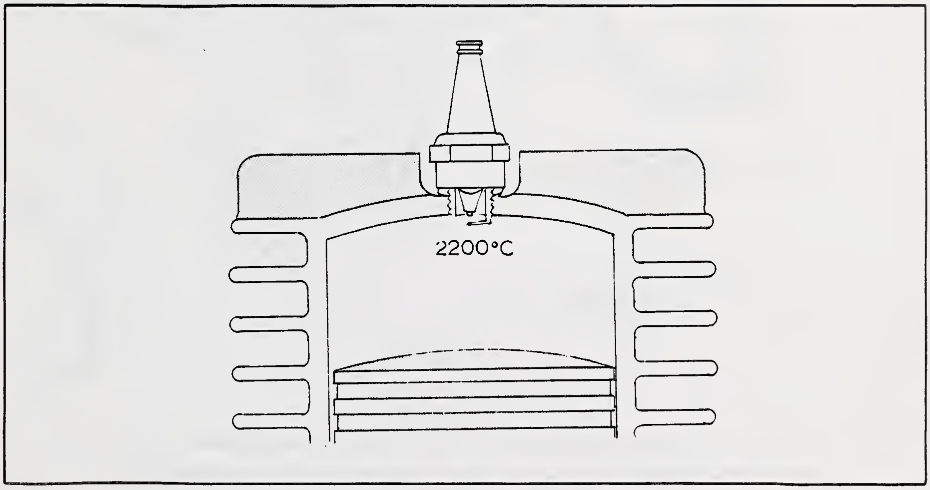
Some two cycle engines do not have oil mixed with the gasoline but have an oil feed to the carburetor. The oil enters the air-fuel mixture in the carburetor in metered amounts to meet all operating conditions. This system varies the amount of oil entering the air fuel mixture. High engine speeds require more lubrication, therefore more oil is injected into the system. This type of system is common on today's motorcycle and snowmobile engines and is referred to an "oil injected engine."



Two Cycle Oil Injected Engine

COOLING SYSTEMS

Internal combustion engines get their power from the heat produced by the burning mixture of gasoline and air inside the cylinder. During the power stroke the temperature inside the cylinder can be as high as 2200°C. Approximately one third of this heat is lost through the exhaust system, another one third is used to develop power, and the remaining one third is soaked up by the cylinder walls, cylinder head and piston. Without some sort of a cooling system, these metal parts would soon soften and melt, or would expand to the point where the piston would become stuck to the cylinder wall. If this were to happen, extensive damage would result.



Cylinder Temperature

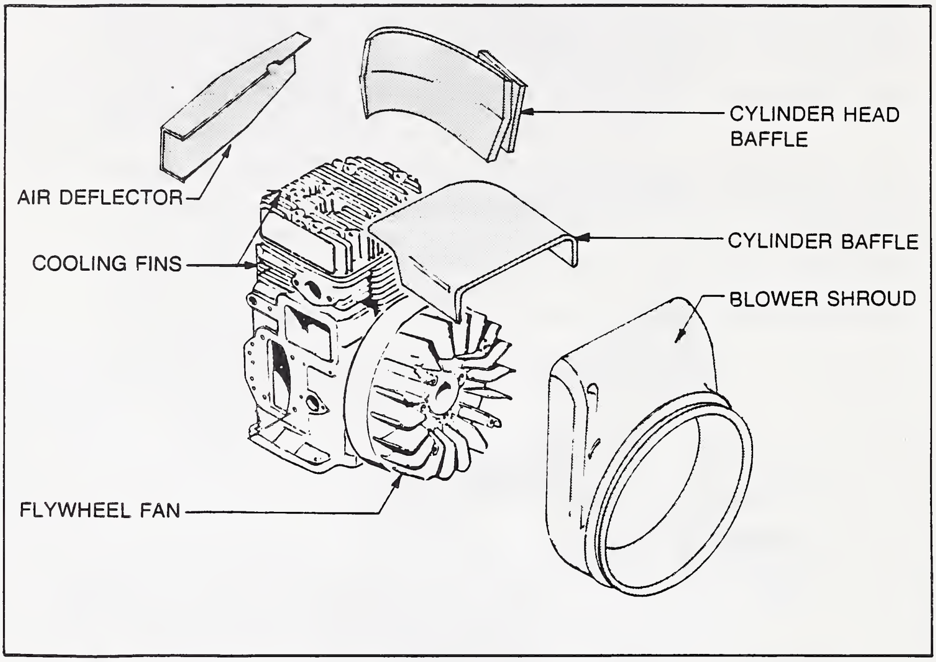
Two systems of cooling are used on small engines: the Air Cooled System and the Liquid Cooled System.

1. Air Cooled Systems

An air cooled engine is one which uses strictly air to dissipate excess heat. Most small single cylinder engines are of the air cooled type because they require fewer parts. This makes them less expensive to purchase and maintain.

Air cooled engines are cooled by a stream of air blown by a fan over and around the cylinder and cylinder head. The fan is most often part of the flywheel. A sheet metal shroud is used to direct the air where it is needed.

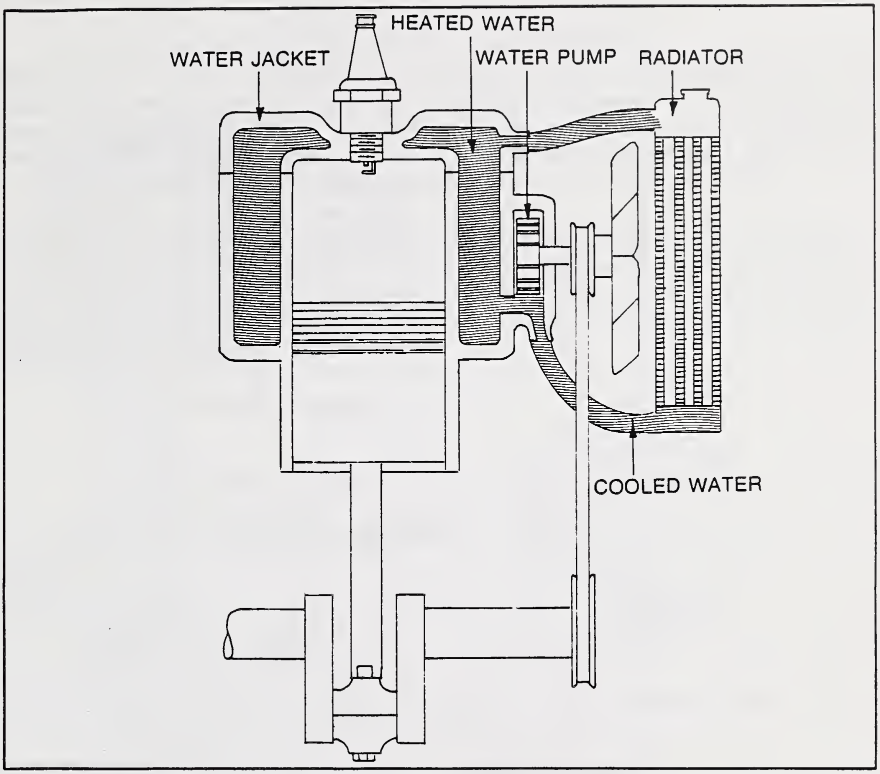
The outside of the cylinder block and cylinder head are covered with cooling fins so that more surface area comes into contact with the air. This greatly increases the speed in which the heat is carried from the cylinder.



2. Liquid Cooled Systems

Instead of cooling fins, a liquid cooled engine is made so that its cylinders are surrounded by hollow passages which are kept full of water. These passages are known as "water jackets."

Most engines of this type have a pump that forces the water through the water jackets from a radiator. Behind the radiator a fan is mounted to draw air through the radiator in order to cool the water.

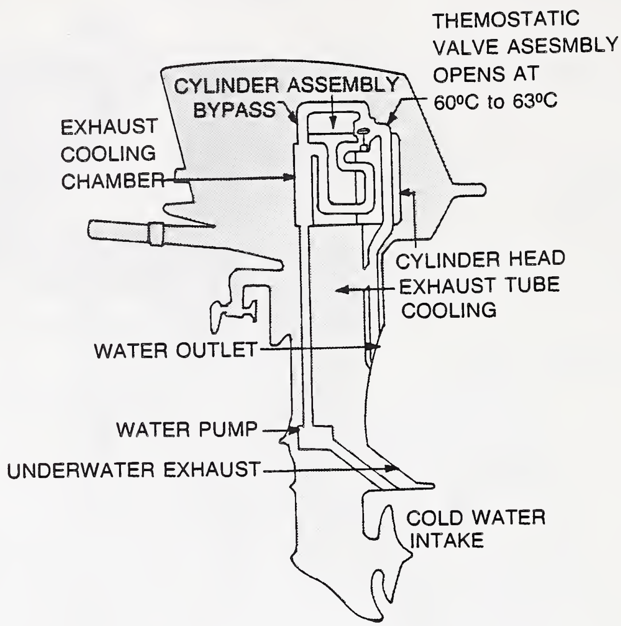


A fan and radiator being used to cool the water for an engine water jacket.

To prevent damage to the water jacket and radiator during winter, a liquid anti-freeze must be added to the water.

Outboard engines used to power boats are water-cooled but have no radiators. The water is simply pumped from the lake or river in which the boat is floating and circulated throughout the water jacket. This heated water is then forced back into the lake or river.

It is important not to over cool an engine. Overcooling would cause the fuel to not burn properly in the cylinder. This would result in carbon deposits forming in the cylinder and spark plug. It would also waste fuel. To prevent this from happening a thermostat is installed in the water jacket to control the flow of water. The thermostat holds the water back until it reaches a certain temperature. When this temperature is reached the themostat opens, allowing the hot water to escape and permitting cool water to take its place.



Water passage through a large outboard motor.

EXHAUST SYSTEM

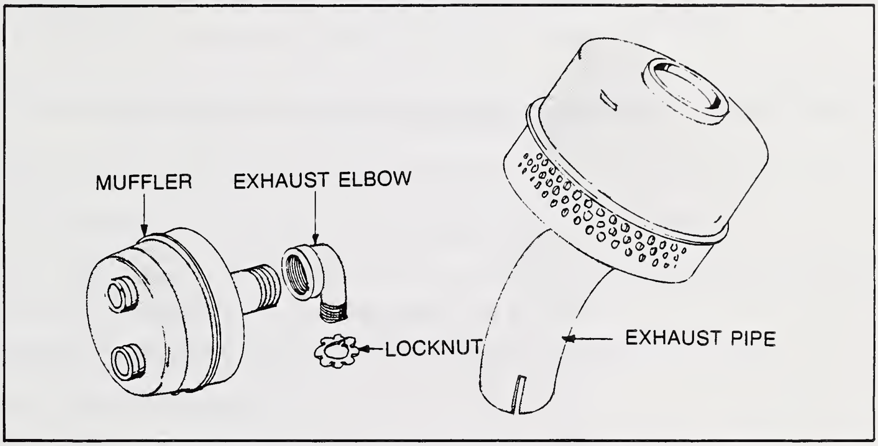
The purpose of the exhaust system is to remove the burnt gases from the cylinder and direct these gases from the engine. The exhaust system of a four-stroke cycle engine includes the exhaust valve, a muffler, and may include an exhaust pipe or elbow. The two stroke cycle has one major difference; an exhaust port takes the place of the exhaust valve.

1. Muffler

A muffler consists of a hollow cylinder which is attached to the exhaust port (opening) of two and four-stroke cycle engines. As the exhaust gases pass through the muffler the noise is deadened or muffled. Mufflers come in a variety of shapes and sizes in order to meet the needs of the particular engine. The muffler is held in place against a gasket by cap screws, a thread fitting, or similar fitting. The location of the muffler on a two-stroke cycle engine is toward the center of the cylinder near the exhaust port. A four-stroke cycle engine has its muffler located toward the top of the cylinder head at the exhaust valve.

A two-stroke cycle engine's muffler does more than muffle the sound or direct exhaust gases away from the engine. It helps to clean (scavenge) all exhaust gases from the combustion chamber and helps to get a fresh fuel-air charge into the cylinder more rapidly. This promotes cleaner and more complete combustion. These mufflers are designed with a megaphone-like device to amplify the sound which speeds up the scavenging gases. Then the muffler silences the sound by means of baffles.

Dirty mufflers cause back pressure. This back pressure slows the discharge of exhaust gases from the combustion chamber. When the gases remain in the cylinder, they occupy room which should be taken by the fresh charge. When a full fresh charge is not admitted, full development of power is impossible. A simple cure is to remove the muffler and clean it.



Types of Small Engine Mufflers

Operating a small engine without a muffler is dangerous. Not only is it a fire hazard, but in the case of two cycle engines, it permits the piston to suck dirt and air back into the combustion chamber. The air leans out the fuel mixture and the dirt increases wear on the piston rings, piston, and cylinder walls.

Caution: Exhaust gases contain carbon monoxide. Carbon monoxide is a deadly, odorless, poisonous gas. Operate an engine in a well ventilated area only.

Complete the following questions and send them in for correction.

1. List the five basic systems involved in the conversion of chemical energy to mechanical energy.

   (a) ____________________

   (b) ____________________

   (c) ____________________

   (d) ____________________

   (e) ____________________

2. What is the major function of the fuel system?

   ____

   ____

3. Why is it so important to use **fresh** gasoline in your small engine?

   ____

4. What is the major caution to be observed when re-fueling a gasoline engine?

   ____

5. What are reed valves and why are they used?

   ____

   ____

   ____

6. Name the three types of air cleaners discussed in this lesson.

   (a) ____________________

   (b) ____________________

   (c) ____________________

7. What are the two functions of a carburetor?

____

____

8. A fuel-air mixture with too much fuel is known as a ______________ mixture.

9. The venturi in a carburetor causes the air to ______________ in speed and ______________ in pressure.

10. Name three methods by which gasoline is supplied to the carburetor from the fuel tank.

(a) ______________________________

(b) ______________________________

(c) ______________________________

11. Describe the function of the following carburetor systems.

(a) High Speed System

____

____

(b) Idle Speed System

____

____

(c) Choke System

____

____

12. What is the purpose of a governor?

____

____

____

13. When the moveable weights of a mechanical governor are fully extended due to centrigugal force the engine speed would ______________________.

14. What is the purpose of an engine's ignition system?

____

____

15. The ______________ ______________ is the low voltage portion of the ignition system.

16. The ______________ ______________ is the high voltage portion of the ignition circuit.

17. What component of an ignition system determines the exact instant a spark will occur?

____

18. Briefly describe (in step form) the procedure of how magneto ignition produces a spark.

(a) ____

(b) ____

(c) ____

(d) ____

(e) ____

19. What two problems may occur if one uses a spark plug with too long a reach?

(a) ____

(b) ____

20. Continuous high-speed operation of an engine requires a ______________ spark plug. (hot or cold)

21. List five functions oil must perform in an engine.

(a) ____________________

(b) ____________________

(c) ____________________

(d) ____________________

(e) ____________________

22. What does the "W" indicate in SAE10W-30?

____

23. How is a two-stroke cycle engine lubricated?

____

____

24. What could happen to a two-stroke cycle engine if only gasoline is used?

____

____

25. Why is a cooling system necessary for gasoline engines?

____

____

26. Why are the cylinder block and cylinder head of an air cooled engine covered with fins?

____

____

27. What is the only major difference between air cooled and liquid cooled engines?

____

____

28. What three functions does the muffler serve?

(a) ______________________________

(b) ______________________________

(c) ______________________________

29. **What is the basic difference between a conventional ignition system and an electronic ignition system?**

____

____

____

EXERCISE 2 **Answer the following true or false questions.**

1. One should always use the type of oil recommended by the manufacturer for a particular engine. (True or False)

____

2. For best performance, the light metal shrouding around an air cooled engine should be removed. (True or False)

____

3. High voltage is necessary to cause current to jump the spark plug gap. (True or False)

____

4. High voltage for the spark plug is created in the primary windings of the coil. (True or False)

____

5. Current flows in the primary circuit when the breaker points are open. (True or False)

____

6. Current flows in the secondary circuit when the breaker points are closed. (True or False)

____

7. For maximum performance, the spark should jump the plug gap just after the piston reaches TDC. (True or False)

____

8. A rich fuel mixture can cause an engine to wear rapidly. (True or False)

____

9. The major result of using stale gasoline in an engine is hard starting. (True or False)

____

10. Engine speed can only be controlled manually by the throttle. (True or False)

____

11. An incorrect setting of the breaker points would affect engine timing. (True or False)

____

12. The voltage produced by a magneto may be as high as 12 000 volts. (True or False)

____

END OF LESSON 3

LESSON RECORD FORM

5037 Small Engines

Revised 91/09

FOR STUDENT USE ONLY

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(If label is missing or incorrect)

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1. BEFORE MAILING YOUR LESSONS, PLEASE SEE THAT:

(1) All pages are numbered and in order, and no paper clips or staples are used.
(2) All exercises are completed. If not, explain why.
(3) Your work has been re-read to ensure accuracy in spelling and lesson details.
(4) The Lesson Record Form is filled out and the correct lesson label is attached.
(5) This mailing sheet is placed on the lesson.

2. POSTAGE REGULATIONS

Do not enclose letters with lessons.

Send all letters in a separate envelope.

3. POSTAGE RATES

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Take your lesson to the Post Office and have it weighed. Attach sufficient postage and a green first-class sticker to the front of the envelope, and seal the envelope. Correspondence lessons will travel faster if first-class postage is used.

Try to mail each lesson as soon as it has been completed.

When you register for correspondence courses, you are expected to send lessons for correction regularly. Avoid sending more than two or three lessons in one subject at the same time.

PERIODIC MAINTENANCE, TUNE UP, AND STORAGE

MINOR TROUBLESHOOTING

Minor trouble shooting means that we will be looking at remedies to fix the problem without dismantling the engine. Major troubleshooting, which means the remedy requires the dismantling of the engine. The following tables list probable causes of the more common engine problems. The lists are compiled from the most common cause down to the rarest cause, so always start to check from the top of the list down.

Some engine troubles may be caused by more than one fault. If the remedy suggested does not correct the trouble, attempt to isolate the additional causes and correct them.

Before making up adjustments or corrections to the engine, carefully check it over to make sure that all fins are clean and all parts are tight and in good working order. An empty fuel tank has caused many hours of wasted time and some bad tempers. Always check the following first, fuel tank is full, filters are clean, intakes and exhausts are not plugged, fuel line is turned on. Only when you are sure should you make adjustments or begin a disassembly process on the engine.

The causes listed in **Table 1** are for two-stroke-cycle, air-cooled engines only. If any particular piece of equipment listed as a possible cause is not on the engine you are working with then look for an alternate mechanism that performs the same or a similar function. For example if the cause is "fuel filter clogged" and the engine you are working on does not have a fuel filter then check for a clogged screen in the fuel tank, plugged or crimped fuel line or plugged carburetor.

Four-cycle engines are covered in the **Table 2** and follow the same format.

If the problem can not be corrected by the remedies listed here or you have checked all probable causes but the condition continues, then the engine may need a general overhaul or major repair as discussed in the next module, **Small Engine Overhaul**.

TABLE 1

Two-Stroke-Cycle Engines Fail to Start or Start With Great Difficulty	
Probable Cause	**Possible Remedy**
No fuel in the tank	Fill tank with the correct fuel-oil mixture.
Fuel shut-off valve closed	Open the valve
Fuel-filter clogged (if it has one)	Service the filter
Clogged fuel line	Remove the line and clean or replace it.
Tank vent plugged	See that the hole is open to allow air into the tank.
Engine flooded	Shut off the fuel, remove the plug and crank the engine. Dry the plug and replace it, then open the fuel valve and start the engine.
Too much oil in the fuel	Drain the tank and refill with the correct mixture.
Water or ice in the fuel	Drain the tank, clean all lines and filters, also fuel pump if there is one and refill with the correct mixture.
Engine over-or under-choked	When starting, close the choke all the way if the engine is cold, half way if the engine is warm. Open the choke when the engine has started.
Carburetor out of adjustment	Adjust the carburetor as per the manual.
Carburetor throttle plate does not open	Check the throttle linkage. Be sure it is free to move. Also clean all parts and adjust so the plate opens.
Spark plug malfunction	Remove the plug, check the points and condition, clean, dry, reset gap and replace it.
Fuel vapor-lock	Allow the engine to cool, supply ventilation, check fuel flow and check why it is overheating.

Two-Stroke-Cycle Engine Misses

Probable Cause	Possible Remedy
Spark plug malfunction	Remove the plug, check, clean, re-gap, replace if required and reinstall it.
Dirt or water in fuel system	Drain the tank, lines, carburetor, clean all parts, re-assemble, fill with correct grade of fuel-oil mixture.
Carburetor out of adjustment	Adjust as per the manual.

Two-Stroke-Cycle Engine Lacks Power

Probable Cause	Possible Remedy
Air cleaner plugged	Service the air cleaner and clean the engine.
Fuel Filter Plugged	Sevice the fuel filter.
Carburetor out of adjustment	Adjust as per the manual.
Exhaust system deffective	Check for plugged exhaust parts, clean the system and replace faulty muffler etc.
Fuel system inopperative	Check choke operation, check, clean fuel system, check for vapour lock.
Carburetor throttle inopperative	Check plate and linkage, repair, clean and replace broken or bent parts and adjust so that it operates.
Spark plug gap incorrect	Remove, check, clean, adjust and replace.

Two-Stroke-Cycle Engine Surges or Runs Unevenly

Fuel tank vent clogged	Use a needle or thin wire to open the tank vent so it can "breathe".
Governor linkage sticking or binding	Free the linkage, straighten or replace bent and broken parts, clean and oil all parts. Reassemble and check for free movement.
Fuel supply low	Fill the tank with correct fuel.
Carburetor throttle linkage binding or sticking	Disassemble the system, straighten or replace all bent or broken parts.
Fuel pump faulty	Check and repair or replace.
Fuel pump dirty	Drain the system, clean and refill with the correct fuel.
Air cleaner dirty	Service the air cleaner
Carburetor adjustment incorrect	Adjust the carburetor.
Fuel filter clogged	Service the fuel filter
Carburetor jet clogged	Service the carburetor (clean and adjust)
Spark plug faulty	Remove, clean, regap and replace
Exhaust gases returning through the carburetor intake	Pipe the exhaust gases away from the air intake; provide proper ventilation.
Fuel vapor lock	Stop the engine and allow it to cool. Provide proper ventilation and check for overheating problems.
Fuel foaming in the tank	Keep the fuel tank full — too much air is mixing with it.

Probable Cause	Possible Remedy
Cooling fins dirty	Keep the engine clean
Engine overload	Remove the overload do not try to force the engine to do more work than it is designed to do. Never use too small of an engine.

Two-Stroke-Cycle Engine Stalls

Carburetor main adjustment too lean	Adjust the carburetor to a richer mixture
Engine overheated	Stop the engine and check section of this table on overheating.
Fuel supply low	Keep the tank as full as is reasonable.
Water or dirt in the fuel system	Drain and clean, replace the fuel with the correct proportions and proper grade of gasoline and oil.
Choke setting is incorrect	Re-adjust the choke.
Carburetor throttle plate closed	Check the throttle linkage. Clean and repair it as necessary, then check for free movement.
Air cleaner dirty	Service the air cleaner, check the gasket and carburetor intake.
Fuel filter clogged	Service fuel filter
Carburetor dirty	Clean the carburetor.
Spark plug defective	Remove, clean, repair or replace, set correct gap and install.
Electrical leads loose or deteriorated	Check and replace leads as necessary. Make sure all connections are tight.
Fuel system	Check and clean fuel system

Two-Stroke Cycle Engine Overheats

Probable Cause	Possible Remedy
Fuel system malfunctioning	Drain fuel system, clean, check for clogged vent breather in tank, check for vapour lock. Refill with proper fuel.
Air circulation	Check for obstructions, shrouding bent or damaged, clean, repair and/or replace damaged parts.
Defective Spark Plug	Replace the plug.
Carburetor dirty or out of adjustment	Clean and re-adjust.
Exhaust gases re-entering engine	Make sure engine has good ventilation and clean fresh air is entering the carburetor.

The following table lists common four-stroke-cycle engine troubles that require minor repairs. Under each of the problems the most common causes are listed in order of priority with their most likely remedy. If the engine is not operating satisfactorily, first check to see if the engine is getting fuel, second see if it is getting spark, third check for compression by removing the spark plug and hold your thumb over the spark plug hole and then turn the engine over. There should be a good pressure developed against your thumb. Now you are ready to check out the trouble by following down the list of possible causes, under the trouble heading.

Some engine troubles may be caused by more than one fault. If the remedy tried does not cure the problem then attempt to isolate further causes and remedy them. Before making any adjustments or corrections to the engine, carefully check that everything is clean with no visible damage and all fluids are full, clean, and of correct type and usage.

The possible causes listed are general to all 4-stroke-cycle engines, and therefore some parts may not be on your engine, if this is so, then check for an equivalent part or go to the next possible cause.

TABLE 2

Four-Stroke-Cycle Engine Fails to Start or Starts With Difficulty

Probable Cause	Possible Remedy
Engine is not getting fuel	Check out fuel system for full tank, blocked passages etc. Clean the system and re-fill the tank with proper fuel.
Engine flooded	Close the fuel shut-off valve, remove the spark plug, and crank the engine. Dry and re-install the plug. Open the shut-off valve and start the engine.
Engine over- or under-choked	When starting, close the choke all the way if the engine is cold; half the way if the engine is warm. Open the choke when the engine has started.
Carburetor adjustment incorrect	Adjust the carburetor settings.
Carburetor throttle plate sticking	Check all linkages and parts that they are clean and free of obstructions, adjust for easy movement.
Carburetor jet clogged	Overhaul and clean the carburetor. Service and clean all the fuel system components and air cleaners.
Spark plug malfunction	Check wiring and plug for cleanliness and correct gap, replace if necessary.
Fuel vapor lock	Allow the engine to cool. Provide the proper ventilation; check cooling system for overheating.
Gasket between carburetor and engine defective	Remove the carburetor and replace the gasket.

Four-Stroke-Cycle Engine Lacks Power

Air cleaner clogged	Service the air cleaner. Check gasket and carburetor intake while the cleaner is off.
Fuel Filter clogged	Service the fuel filter
Carburetor out of adjustment	Adjust the carburetor settings.
Muffler or exhaust clogged	Clean and or replace the exhaust system.
Choke stuck partially closed	Open and clean the choke so it operates freely.
Fuel tank vent plugged	Clean the vent hole with a fine wire.
Fuel supply low	Check that the tank has sufficient fuel.
Vapor lock	Stop the engine and allow it to cool. Check for overheating problems.

Probable Cause	Possible Remedy
Carburetor throttle stuck	Check and clean all parts and linkages repair or replace all bent or broken parts. Adjust them for free movement.
Fuel system dirty	Check, clean and replace fuel in the system.
Governor linkage binding	Check the linkage for bent parts or obstructions.
Spark plug faulty	Remove, clean, check, re-gap or replace with a new one.
Crankcase oil level incorrect or improper oil grade	Fill the crankcase with the proper amount and grade of oil to provide oil level. Do not overfill or underfill.
Carburetor jet clogged	Clean the carburetor.
Engine overload	Check that the engine is not being used for a job that requires a larger engine.

Four-Stroke-Cycle Engine Knocks or is Noisy

Fuel octane rating is too low	Drain the system and re-fill with the correct grade of fuel.
Engine overheating	Shut the engine off. When cool check causes and engine overheating.
Bent fan or Blower Housing	Remove the housing; check and straighten parts or replace them.
Crankcase oil level low or oil grade is incorrect	Fill the crankcase to the correct level mark with the correct grade of oil.
Carburetor adjustment is too lean	Re-adjust the carburetor to a richer mixture.
Spark plug is of the wrong heat range	Remove the plug and install the correct one as per manufacturers recommendations.

Four-Stroke-Cycle Engine Overheats

Crankcase oil level incorrect too high or too low. Incorrect grade of oil.	Check the crankcase and fill to correct level with the proper grade of oil.
Cooling air flow restricted	Clean, check and straighten or replace all shrouds, screens, fins and blowers.
Shrouding missing, bent or damaged	Replace or repair all defective parts of the shrouding.

Four-Stroke-Cycle Engine Misses

Probably Cause	Possible Remedy
Spark plug malfunction	Remove, clean, regap, check wires, install. Use a new plug if required.
Fuel supply low or dirty	Check for proper fuel level, check for clean fuel. Probably have to clean fuel system and re-activate with fresh, correct fuel.
Carburetor out of adjustment	Re-adjust
Cooling fins clogged	Clean all fins and cooling surfaces.
Defective spark plug	Repair and adjust or replace the plug.
Carburetor out of adjustment	Re-adjust carburetor
Carburetor jet clogged	Ensure that exhaust gases can not enter the carburetor.
Excessive load	Remove the excessive load.

Four-Stroke-Cycle Engine Surges or Runs Unevenly

Probable Cause	Possible Remedy
Fuel tank vent plugged	Use a needle or fine wire to clear the vent
Governor linkage sticking	Check and straighten all bent parts. Clean or replace as necessary. Oil lightly and ensure that all parts move freely.
Fuel supply is low or dirty	Fill to operating level with correct grade of fuel or clean entire system and refill.
Carburetor of manifold connection loose of faulty causing air leaks	Tighten all connection and replace any damaged gaskets.
Carburetor choke or linkage binding	Same remedy as for sticking governor linkage.
Air cleaner dirty	Service the air cleaner
Carburetor out of adjustment or dirty	Re-adjust or service the carburetor.
Fuel line or filter clogged	Clean and/or replace the lines or filter.
Spark plug faulty	Clean and re-gap or replace as necessary.
Inconsistent electrical flow	Check all leads and connection for breaks corrosion or looseness — repair as needed.
Exhaust gases entering the carburetor	Ensure that only clean fresh air enters the carburetor.

Cooling fins dirty	Ensure that all cooling surfaces are clean.
Engine overload	Remove the overload.

Four-Stroke-Cycle Engine Stalls

Carburetor adjustments too lean or to rich	Adjust to proper settings
Engine overheated	Stop the engine till it cools and check for overheating problem.
Fuel supply incorrect	Clean and check fuel system. Refill with correct type grade of fuel.
Air cleaner clogged	Service the air cleaner.
Carburetor dirty	Service the carburetor.
Improper electrical supply	Check for broken or loose wires and connections — repair or replace.
Spark plug	Check, clean, re-gap or replace.
Exhaust fumes entering the carburetor	Ensure that only clean fresh air enters the carburetor.

DIAGNOSTIC TESTS

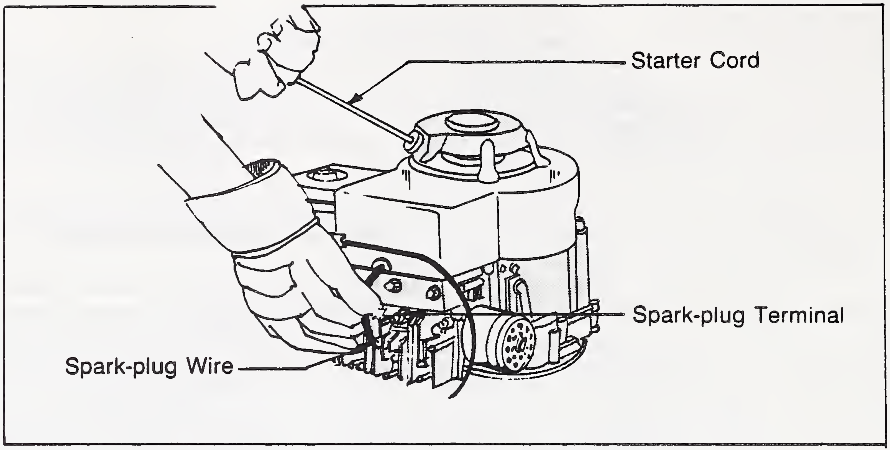
In order for a gasoline engine to run, it requires a strong spark, a proper air-fuel mixture, and sufficient compression. When the engine fails to start, one of these elements is missing. The basic trouble spot can easily be determined by performing a simple diagnostic test without disassembling the engine. A simple test of each basic system can quickly eliminate suspicions by reducing the number of suspect parts.

Rule out the most obvious possibilities first: fill the fuel tank with fresh fuel, check the throttle and choke position, check to make sure the fuel is turned on, and make sure the switch (if so equipped) is turned on.

After the obvious has been checked proceed with this simple four-step test.

1. Testing the Ignition System

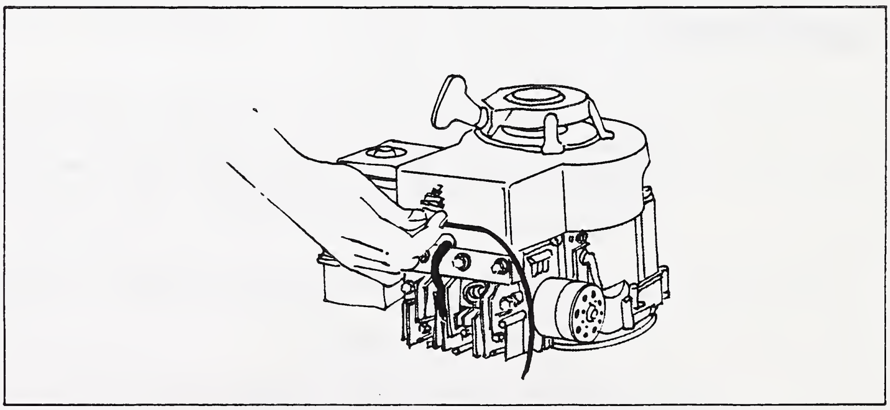
Disconnect the spark plug wire from the spark plug terminal. Guard against shock by either wearing a rubberized glove or by supporting the wire with an insulated screwdriver. Hold the wire 5 mm from the terminal and attempt starting the engine. If the system is fuctioning correctly, a blue spark should jump from the wire to the terminal, making a sharp snapping sound. If there is no spark, there is a malfunciton somewhere in the ignition system and repair of the system components is necessary. The repair of this system will be discussed later in this lesson under tune up.



Caution: The engine could start — be prepared.

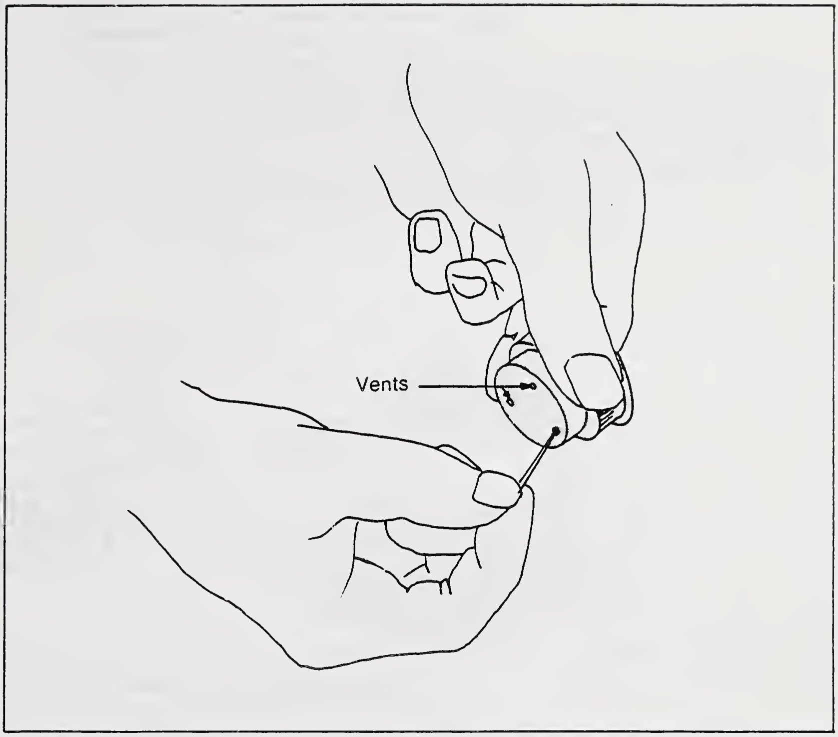
2. Check Fuel Flow

Use a spark plug wrench to remove the spark plug from the cylinder head. Inspect the firing end of the spark plug for wetness. If fuel is entering the cylinder, the plug tip will feel and look wet. If the plug is dry, there could be a fuel flow problem. Check for either a blockage or malfunction in the carburetor, a blockage in the fuel line or fuel tank, or stuck intake valve. If gasoline vapours pour out of the cylinder, the engine is probably flooded. Follow the procedure for starting a "flooded engine." Then check for the cause, possibility a clogged air filter or improper starting procedure.

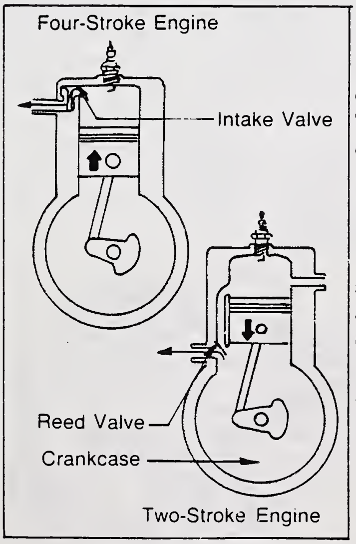


(a) Dealing With Fuel Flow Problems

(i) **Clogged gas cap** — Remove the gas cap and try to start the engine. If the engine runs with the gas cap off, the vents in the cap are clogged. Unclog the vents by pushing a pin or wire through the vent holes.



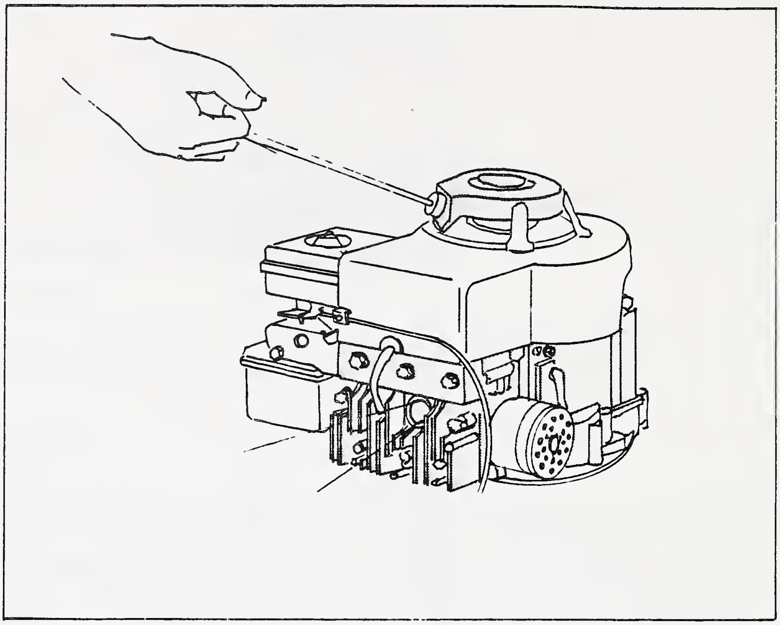
(ii) **Stuck Intake or Reed Valve** — With the air cleaner removed, place your hand close to the top of the carburetor. Spin the engine over rapidly. A blast of air from the carburetor indicates a serious valve problem.



If the engine is a four-stroke cycle, the rush of air is caused by an intake valve stuck open. The open valve allows the fuel-air mixture to escape back through the carburetor. Repair of valves is discussed in the next module, "Small Engine Overhaul."

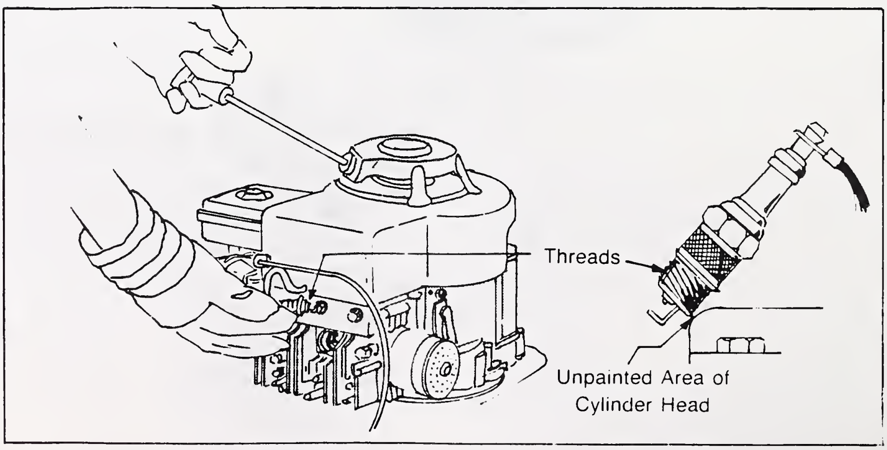
If the engine is a two-stroke cycle and the same symptom appears then the reed valves are not closing properly. As the piston moves downward, the air-fuel-oil mixture is forced back through the carburetor. Again, repair of such a problem is discussed in the next module.

(iii) **A flooded engine** — Remove the spark plug and wipe the tip dry. Spin the engine over rapidly to blow excess gasoline from the combustion chamber. Insert the spark plug properly and attempt to start the engine.



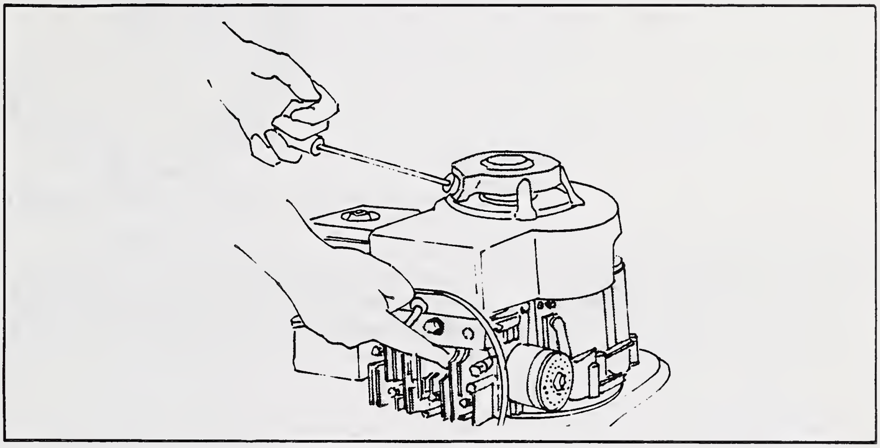
3. Test the Spark Plug

Clean any deposits from the tip of the spark plug. Reconnect the spark plug wire to its terminal and hold the threaded portion of the spark plug firmly against the bare metal of the engine block. (Away from the spark plug hole to prevent a flash.) Spin the engine rapidly and watch for a strong spark between the electrodes. A steady spark indicates that the ignition system, as well as the spark plug, are functioning satisfactorily. If there is no spark, the spark plug is defective and requires servicing. (Spark plug service is discussed later in this lesson.) This method of testing tends to be more reliable than the procedure discussed in step one and there is no chance of the engine starting with the plug removed. In some rare occasions, the spark plug may fire out of the engine but may not fire when in the engine and under compression.



4. Checking Compression

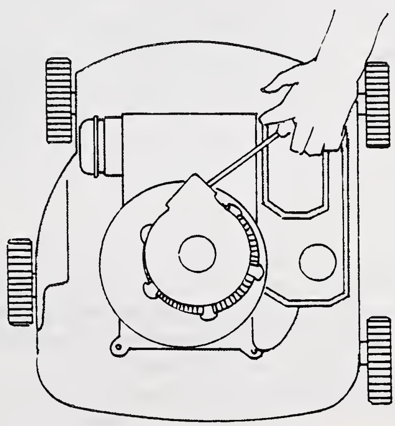
With the spark plug removed hold a finger over the spark plug hole and spin the engine over. The air pressure inside the cylinder should alternately draw your finger toward the hole and blow it away. If you do not feel air pressure, lack of compression due to a leaking head gasket, worn valves, worn piston or piston rings are likely. A further and more extensive investigation will be necessary.



(a) Finding Causes of Low Compression

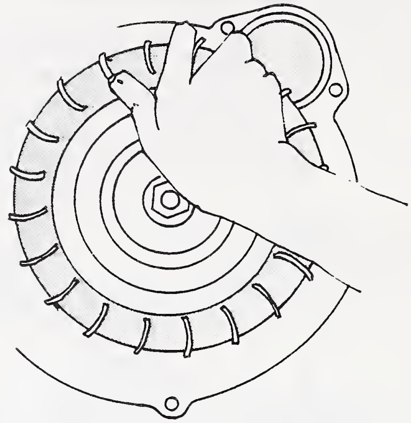
Some small engine repair manuals may suggest other methods for checking compression. Check your manual for the method suggested for your particular engine model.

(i)



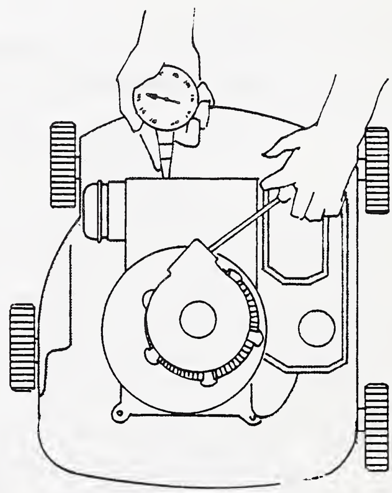
Note resistance when pulling the starter rope.

(ii)



Note the resistance when rotating the flywheel in the opposite direction of normal rotation.

(iii)



Manufacturers may suggest using a compression gauge to check cylinder compression. The specific repair manual will indicate the reading that should be obtained.

If the initial compression test indicates a compression problem, an oil test should be made. Squirt a small amount of motor oil into the cylinder through the spark plug hole. Take another compression test. If this second test indicates increased compression then the piston and piston rings may be worn and the engine will need a major overhaul.

If the reading does not increase:

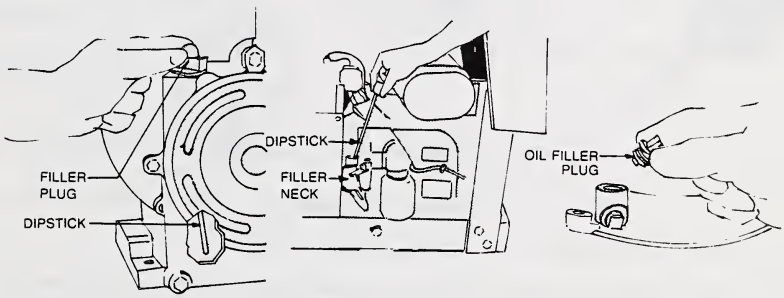
(a) **Two-stroke cycle engine** — the compression loss is due to a worn or leaking cylinder head gasket. (Refer to Tune up section).

(b) **Four-stroke cycle engine** — the compression loss may be due to a leaky head gasket or possibly a stuck intake or exhaust valve, the latter requiring major overhaul.

PERIODIC MAINTENANCE

1. **Change Engine Oil** (Four-stroke cycle engine)

The level of the oil in the crankcase should be checked before starting the engine and each time you refuel the engine. Some engines have dipsticks attached to the filler plug while with others you have to look directly into the filler tube to check the oil level. Oil level should be kept to the top of the filler hole if there is no dipstick.



Oil collects dirt and metal particles, soot, sludge, water and raw gasoline. Through prolonged use, a point is finally reached where the oil is unable to absorb contaminants and still remain an effective lubricant. This is further compounded by the fact that most small engines do not have an oil filter to help filter out the metal and grit particles. The contaminants accumulate and since they are circulated throughout the engine they increase wear on the moving parts.

Most manufacturers recommend changing oil every 25 hours of operation under ideal conditions. If the engine is operated in dusty conditions, change the oil more often.

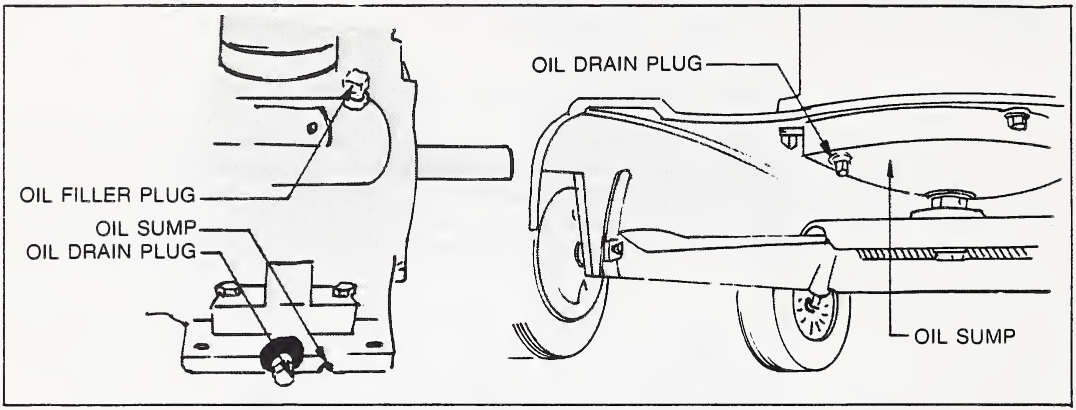
The oil in a new engine should be changed after the first 2 to 5 hours of operation (to get rid of metal particles).

The following steps are recommended for changing your engine oil.

(a) **Operate the engine until normal operating temperature is reached.** Oil will drain more completely and more contaminants are removed when the oil is hot.

(b) **Stop the engine. Disconnect the spark plug wire.**

(c) **Locate the drain plug.** Drain plugs are located on the outside bottom edge of the oil sump or under the oil sump.



(d) **Clean the dust and dirt from around the plug before removing it.**

(e) **Remove the drain plug with the proper size wrench.** Never use pliers as they will gradually round the corners off the plug.

(f) **Allow the crankcase to drain for at least five minutes in order to remove as much dirt and oil as possible.** The engine should be tilted slightly toward the drain.

(g) **Replace the drain plug.**

(h) **Refill the crankcase with the recommended type and amount of oil.** (Specified in the operator's manual.) Insert a clean funnel into the oil filler hole to prevent spilling. Wipe any excess oil from around the filler plug and replace.

(i) **Connect the spark plug wire and start the engine.**

(j) **Check for any oil leaks.**

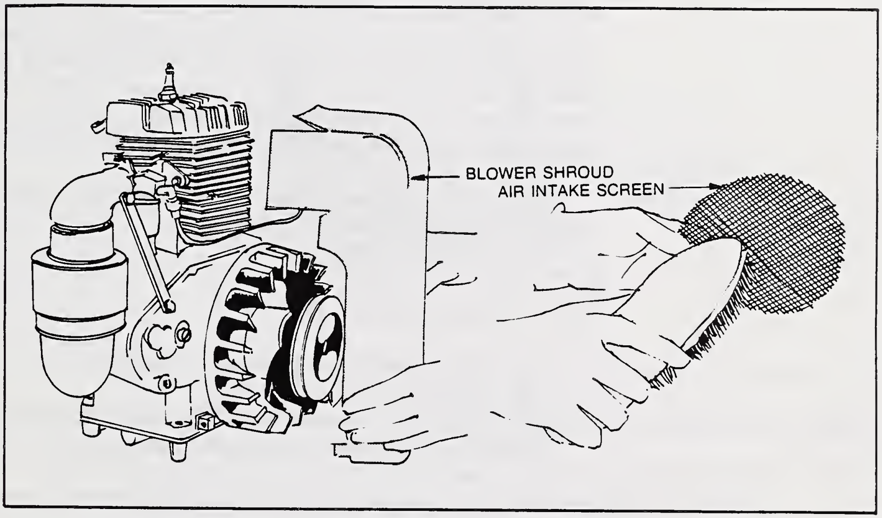
(k) **Stop the engine and check the oil level. Top up oil level if necessary. Do not overfill the crankcase as this can cause foaming and excess oil to burned in the combustion chamber.**

2. Cooling System Service (Air cooled engines)

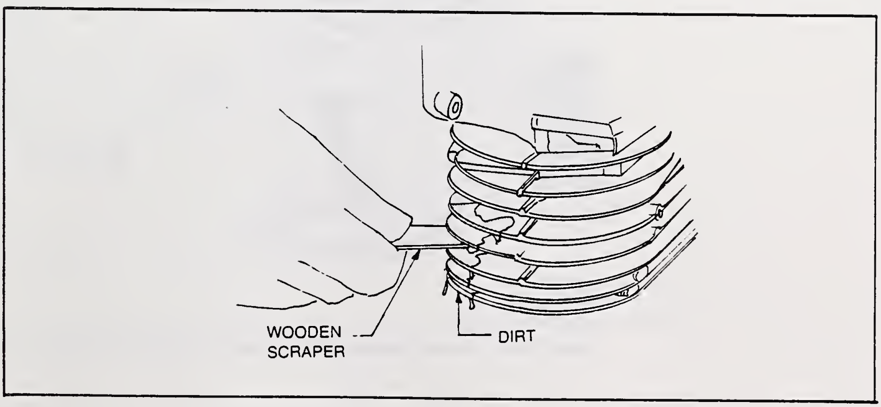
Since most small engines are of the air cooled variety we will concentrate our discussion on this type. Excess heat of combustion is removed by air circulating over the engine. The air enters through a screen in the shroud which covers the flywheel. The rotating flywheel forces air outward and the shroud directs it across the engine.

To prevent any restriction of air flow, it is very important that the air intake screen and cooling fins on the engine be kept clean. Scratched piston rings, a scored cylinder wall, and scoring of the piston can be the result of a "hot spot" created from the blockage of just one air passage.

Remove the blower shroud from the engine (a) to gain access to the cooling components. A stiff bristled brush should be used to remove accumulated grass and debris from the air-inlet screen (b).



Use a wooden scraper to clean dirt from the cooling fins. Steel scrapers scratch the surface which will later collect dirt. Use compressed air to blow the particles out of confined spaces. Remember to protect your eyes when working with compressed air — **wear goggles.**



Take care not to break any of the cooling fins or blades on the flywheel when servicing. Broken flywheel blades will case the flywheel to be out of balance. If any fins are missing, the flywheel needs to be replaced.

When reassembling the shroud and baffles, be sure that all screws and nuts are tightened securely and that none are missing. If cylinder head bolts had to be removed, be sure to torque them according to specifications given in the repair manual.

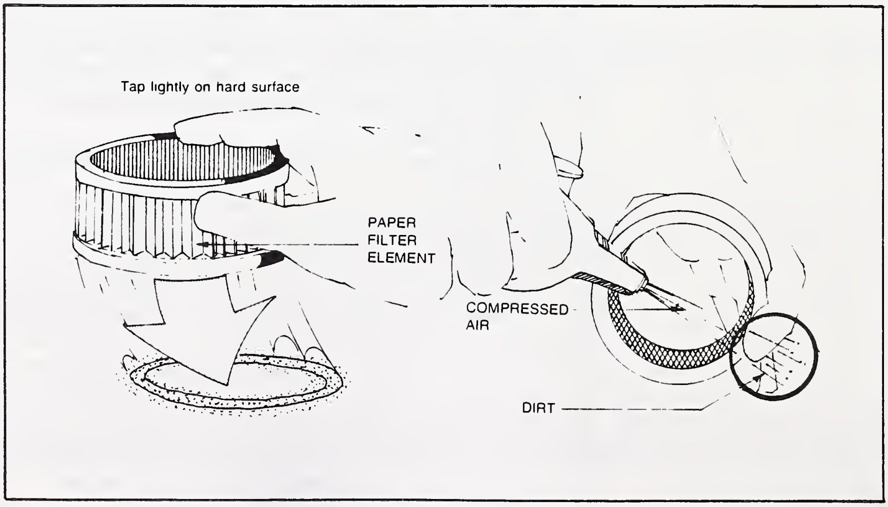
3. Air Cleaner Service

The air cleaner requires the most extensive and most frequent service. A clean air filter is essential to efficient operation and long engine life. An air cleaner must be kept clean in order to provide adequate clean air for combustion. A clogged filter will restrict air flow through the carburetor producing a choking effect on the engine. This will cause the engine to run on a rich mixture resulting in loss of power, spark plug fouling, and carbon build up. The excess gas will dilute the oil film on the cylinder walls decreasing lubrication which will lead to excessive wearing of parts. The oil in the crankcase will be diluted due to the excess fuel passing the cylinder rings.

Lesson three discused three types of air filters used on small engines. Each type requires different methods of cleaning.

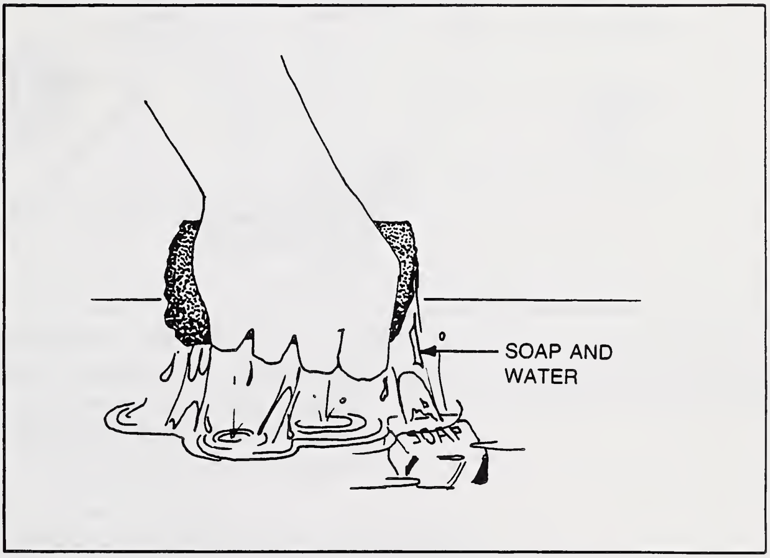
(a) Dry Paper Type Filter

(i) Clean the area around the air cleaner.
(ii) Remove the filter element.
(iii) Tap the filter element lightly on a flat surface to jar the dirt loose.
(iv) Clean the element by blowing low pressure, compressed air from the inside out.

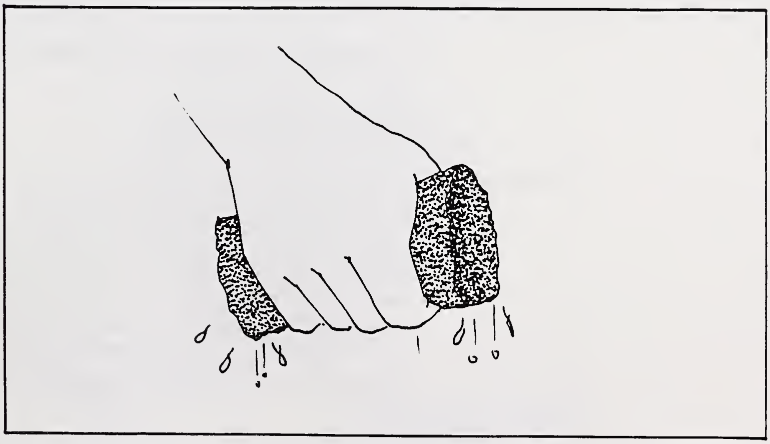


(b) **Polyurethane Filter**

(i) Clean the area around the air filter.
(ii) Remove the foam element from its container.
(iii) Wash element thoroughly with soap and warm water. (Household detergent is best.)
(iv) Squeeze out the water and dry it by squeezing it inside a dry rag or using compressed air.



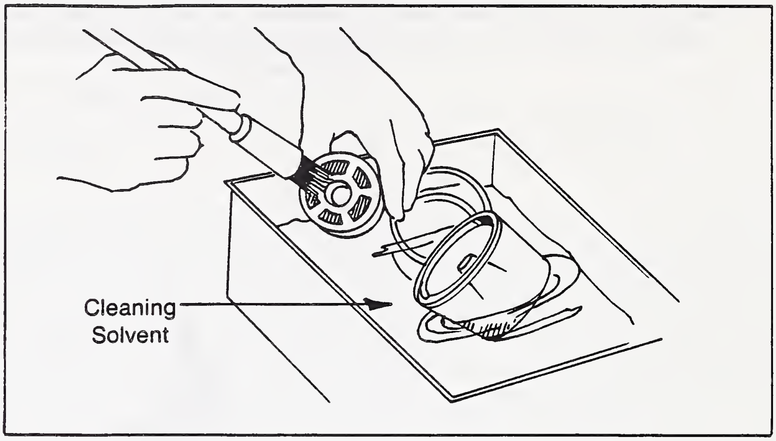
(v) Add a small quantity of oil (one or two tablespoons, the same type and grade as used in the crankcase), to the element.
(vi) Squeeze the element to distribute the oil throughout the element as well as to remove any excess oil. Too much oil will choke the engine.



(vii) Install the filter element and secure the cover.

(c) **Oil Bath Air Cleaner**

(i) Remove the air cleaner from the carburetor.
(ii) Lift the filter out of the bowl and pour the dirty oil out of the reservoir.
(iii) Wash the bowl and filter element in cleaning solvent (such as kerosene).



(iv) Refill the bowl with clean oil (crankcase type and grade) to the oil level indicator line on the bowl.
(v) Check the gaskets for damage. Replace if necessary.
(vi) Install filter element and attach to the carburetor.

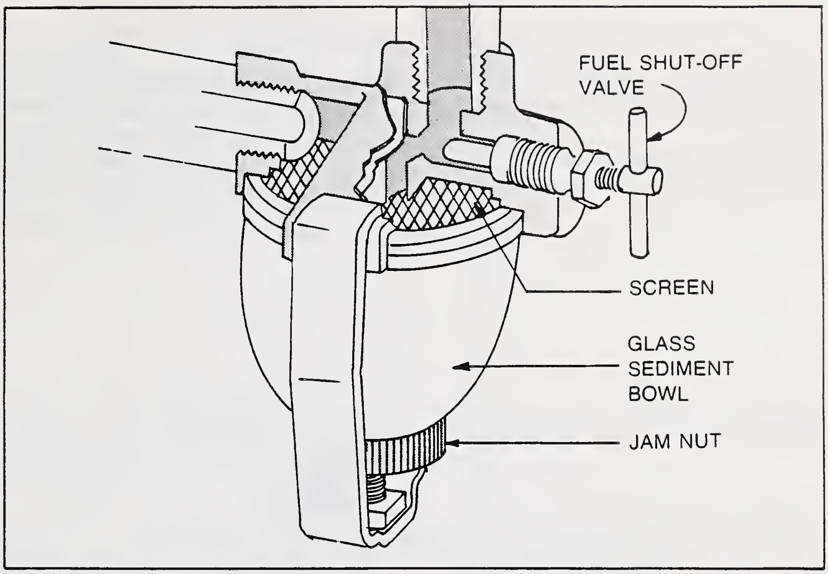
Caution: Never use gasoline as a cleaning fluid as it posses a serious fire and explosive hazard.

4. Fuel Tank and Fuel Filter Service

Three types of fuel strainers (or filters) are commonly used in small engines.

(a) **Sediment-Bowl Type**

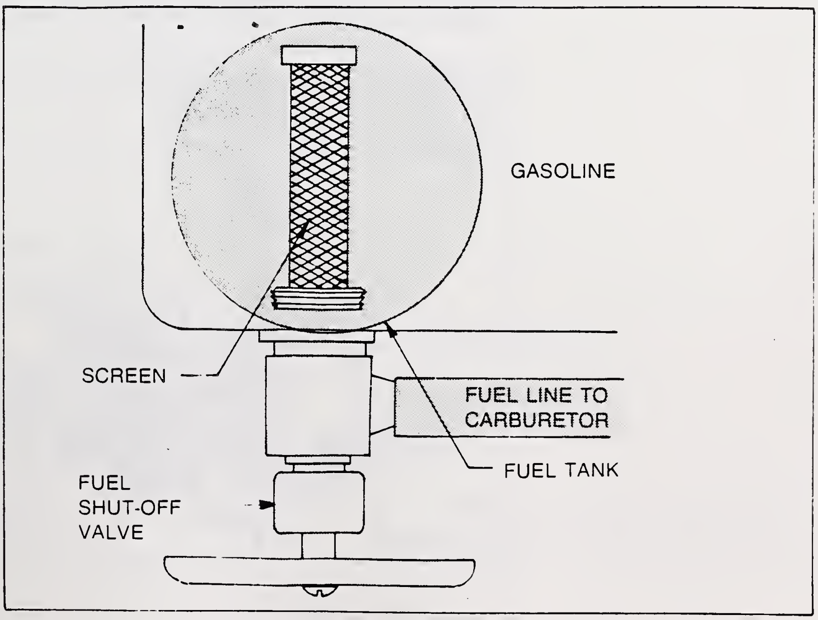
The sediment bowl allows any dirt or water to settle out of the fuel. To clean this type of strainer system, close the fuel shut-off valve to prevent fuel from flowing out of the tank while the glass bowl is off. Loosen the jam nut and remove the bowl using a twisting motion to prevent damage to the cork gasket under the bowl. The strainer screen is usually held in place by the clamping action between the bowl and gasket. Wash the screen and bowl in solvent. Open the fuel shut-off valve and allow a small quantity of fuel to drain out into a container. This will remove any dirt that may be in the fuel line.



Install the filter screen, gasket, and glass bowl. You may want to reverse the old gasket to get a better seal or replace it with a new gasket. To eliminate air that might cause an air lock in the line, open the fuel shut-off valve before tightening the jam nut.

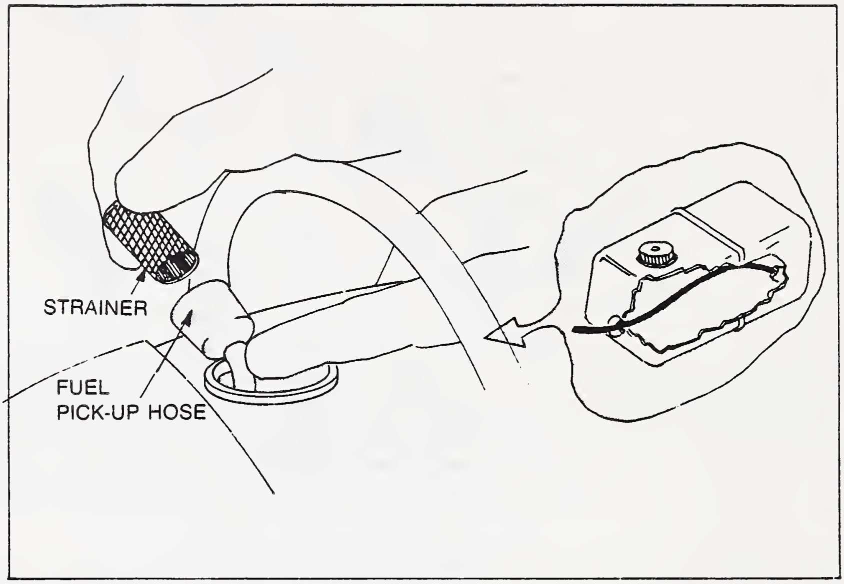
(b) Screen in the Fuel Tank

Most fuel tank screens are removed by unscrewing the fuel shut-off valve or tank fitting on which the screen is mounted. The screen should be washed in solvent and blown dry with compressed air. If the screen is permanently mounted in the fuel tank and non-removable, it will be necessary to remove the fuel tank from the engine. The fuel tank should be washed out with solvent several times. This will clean both the screen as well as the tank.



(c) Screen Attached to the Fuel Line

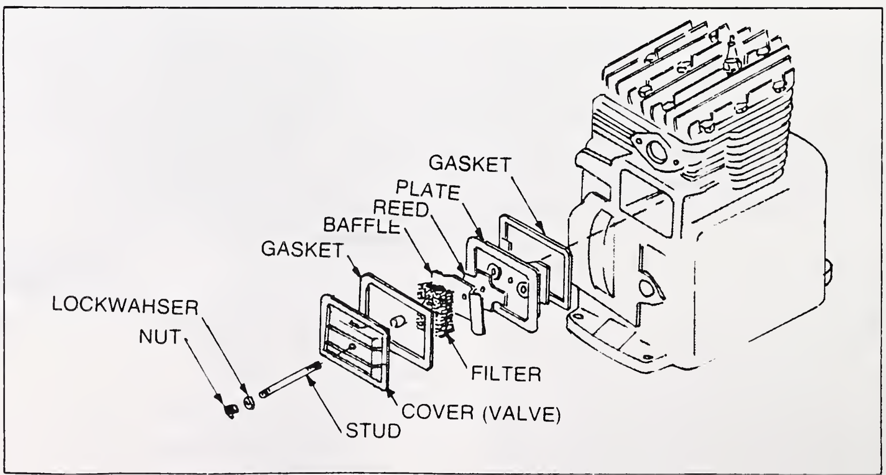
This type of fuel strainer has a weighted screen attached to a flexible hose inside the fuel tank. Remove the strainer from the fuel tank using a bent wire. Separate the strainer from the hose and wash it in solvent. Dry the strainer with compressed air and reinstall. This type of strainer is most commonly found on chain saws.



5. **Crankcase Breather Service** (Four Cycle Engines Only)

Combustion gases may seep past the piston rings. This seepage or blow-by can build up pressure in the crankcase if not permitted to escape. Four stroke-cycle engines use a crankcase breather to allow the blow-by gases to escape.

Various types of crankcase breathers are used. One type uses a mesh type filter and a reed valve. The reed valve opens on the downward stroke of the piston releasing crankcase pressure.



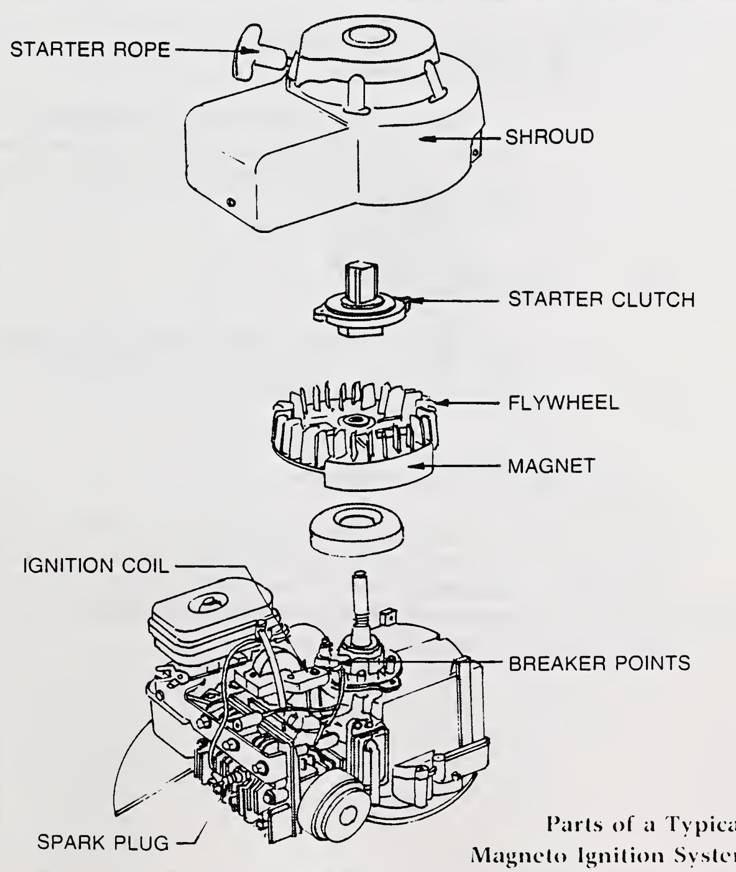
Other engines use a check ball type or floating disc type of breather. Most lawnmower type engines use a reed system (as shown above) with a tube leading to the carburetor. This type of system burns the blow-by gases in the combustion chamber.

If the engine shows signs of an oil seal leak, this is a good indication of a clogged crankcase breather which may require servicing. Your specific engine repair manual will discuss methods of service.

TUNE-UP

As a gasoline engine is used, parts begin to wear and power and performance gradually diminish. Regular tune-ups will restore an engines performance as well as reveal problems before the engine breaks down or requires major overhaul work.

Small engines should receive a complete tune-up before every new season of hard use or after every forty to fifty hours of operation. A complete tune-up should include the adjustment of the magnetic ignition system to manufacturers specifications, adjusting engine timing, adjusting the carburetor, as well as a thorough cleaning and inspection of the entire engine.



Parts of a Typical Lawnmower Magneto Ignition System (Four Cycle)

A tune-up procedure should always be done in a fixed order. The following steps are suggested for the tune-up of a four stroke-cycle lawn mower type engine.

1. Diagnostic Tests

Test the ignition system for spark, check the fuel flow, and check the compression in order to detect trouble spots in the system. Refer to **Diagnostic Tests** on page eleven of this lesson.

2. Service of Spark Plug

(a) Condition

Check the condition of the spark plug. The condition of the spark plug gives some indication as to the condition and operation of the engine.

(i) Normal

The tip should have a light coating of light brown or grey deposits. If the plug has only slightly worn electrodes it may be cleaned, regapped, and reinstalled.

(ii) Carbon Fouled

The tip is covered with fluffly black deposits, a result of overly rich fuel mixture, excessive idling, or a plug of incorrect heat range. If electrode wear is not too severe the plug may be serviced and reinstalled. Check the cause of the plug problem.

(iii) Oil Fouled

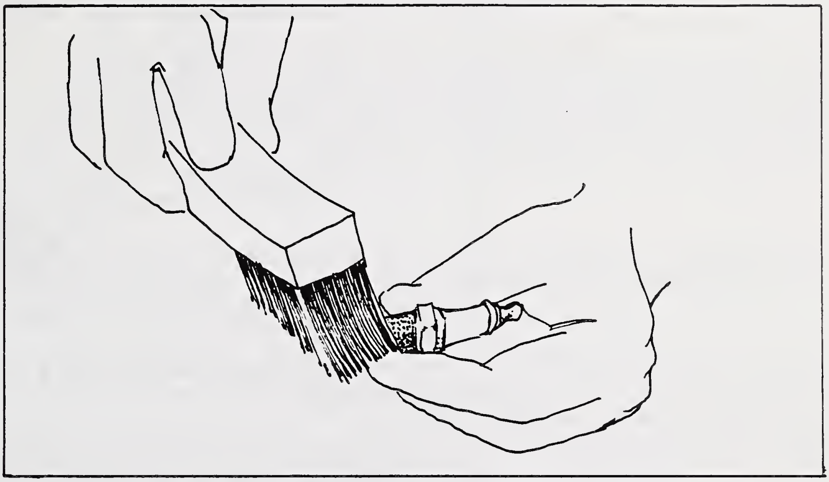
The tip is covered with wet, black, oily deposits cause from oil leaking past the rings or valve stems. A major engine overhaul may be necessary to correct this condition.

(iv) Blistered Insulator

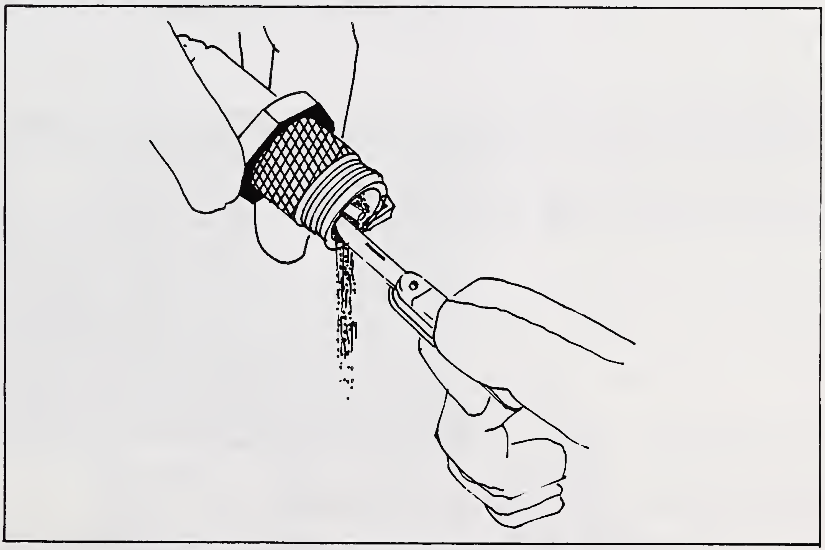
This condition is the result of overheating. Overheating may be caused by using the wrong spark plug, cooling system problems, bad valves, low-octane fuel, and incorrect ignition timing. Replace the spark plug and be sure to correct the cause of the overheating problem.

(b) Cleaning the Spark Plug

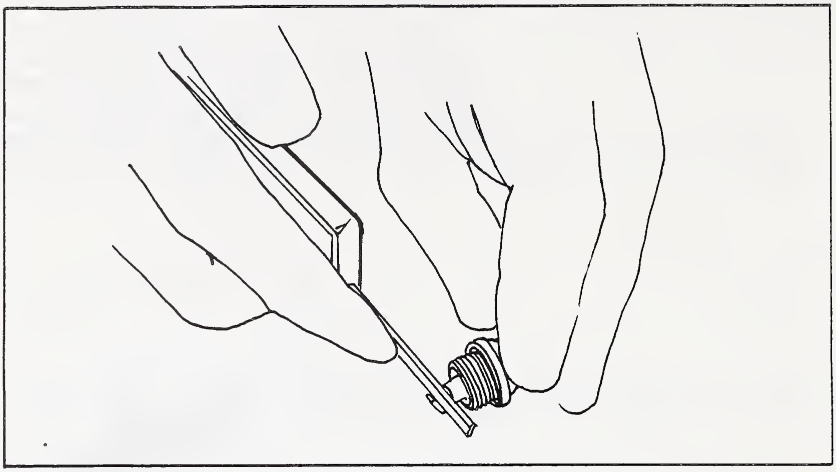
Many manufacturers advise against the the use of a sandblasting unit to clean the spark plug. Deposits should be removed using a wire brush and light scraping with a pen knife. File the electrodes until a bright, flat surface is produced. If deposits cannot be removed with light scraping the plug should be replaced.



Wire brush the spark plug threads.



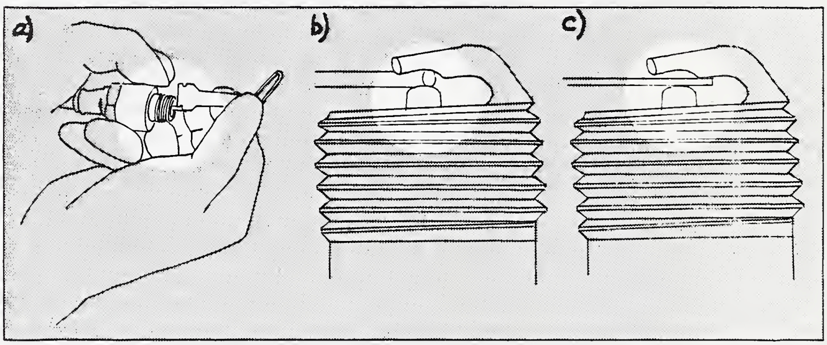
Scraping hard deposits with a pen knife.



File electrodes flat with a point file.

(c) **Adjust the Gap**

Manufacturers do not preset the electrode gap. Set the gap according to specifications using an electrode bending tool (See (a) below). Check the gap with a wire feeler gauge (See (b) below). A flat feeler gauge will give an inaccurate reading as shown in illustration (c) below.



(d) **Install the Plug**

All spark plugs should be tightened to the torque value specified for that plug and engine. If a torque wrench is not available, tighten the spark plug finger tight then turn it another one-third turn using a spark plug wrench. If a spark plug is not torqued properly it can seriously obstruct the flow of heat greatly reducing the life expectancy and efficiency of spark plug operation. Also if the plug is installed too loosely it could vibrate loose and damage the threads in the cylinder head. Check the condition of the spark plug wire and boot.

3. Remove the Engine Shroud

Remove the shroud taking note of where the screws and bolts come from. Since the shroud has been removed, this would be a good time to inspect the starter assembly.

(a) Servicing the Manual Starter

The starting cord that is usually supplied by the manufacturers is constructed of a special material designed to give a good working life. Ordinary rope of the same diameter will not last very long, so always replace damaged parts with those recommended by the original manufacturer only. To get at the starter rope holder for replacement, other parts usually must be removed first, use this opportunity to check these parts for damage.

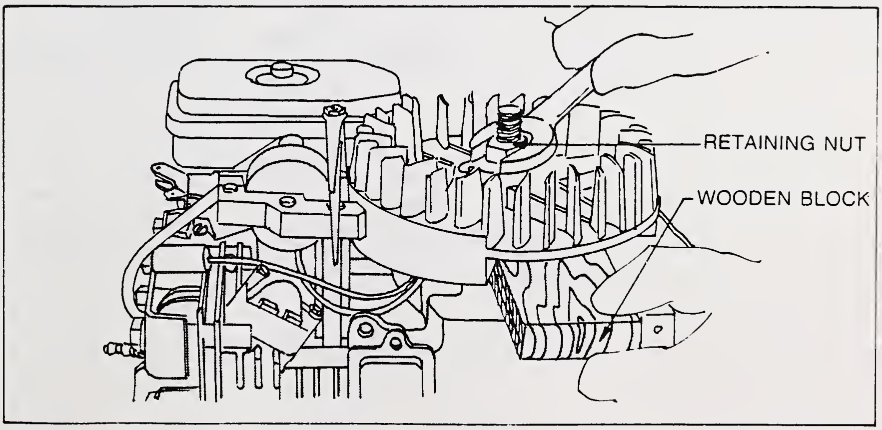
Caution: Make sure all tension is out of the starter coil spring before opening the housing completely. Injury could result if this spring is still under tension when the cover is released.

The end of the rope must be fastened securely to the starter hub or reel. Check the manual for your specific engine when installing a new rope — some are wound clockwise while others are anti-clockwise. If no manual is available pay particular attention as to how the old rope was on and how each part comes off and also the position and direction of the tension spring and pulley hub.

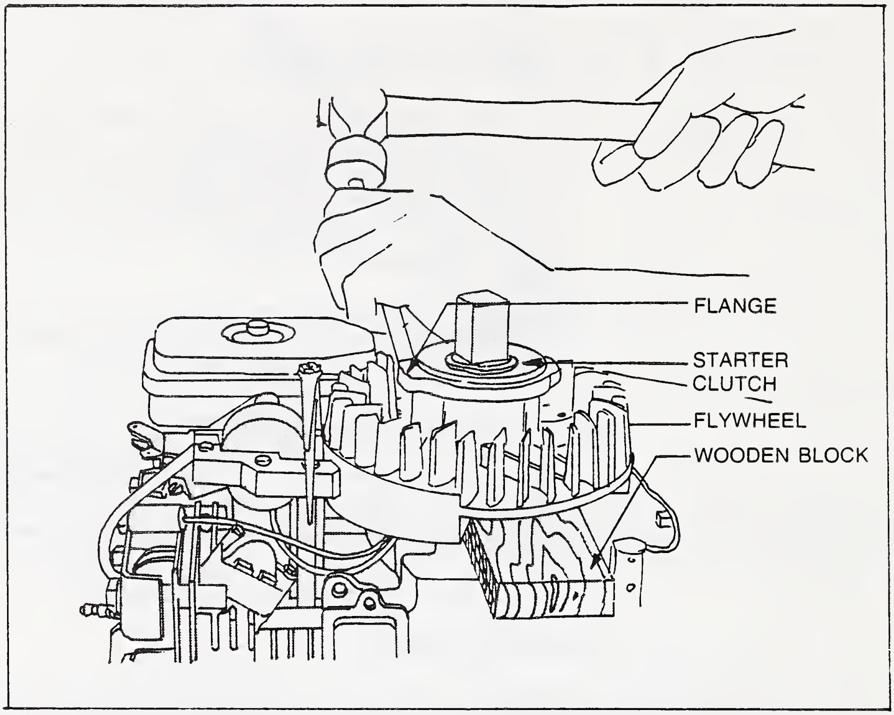
4. Remove the Flywheel

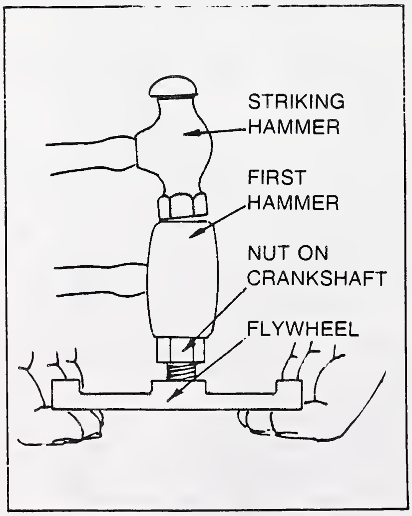
The flywheel fits over the tapered crankshaft. A key prevents it from turning on the shaft. It is usually held in place with a retaining nut or a threaded starter clutch.

To remove the retaining nut, first secure the flywheel with a flywheel holding tool or wedge a block of wood between the flywheel and the chasis. Loosen the nut with the proper size wrench.

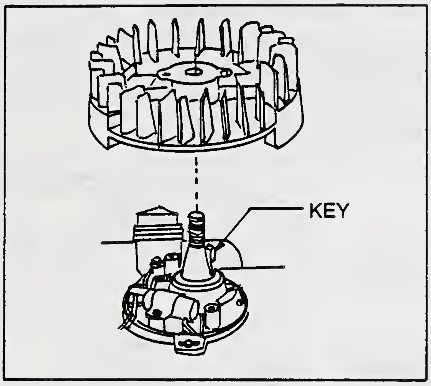


To remove the starter clutch, secure the flywheel as previously mentioned. Using a ball peen hammer and a wooden dowel (a special tool is available) firmly tap on the side of the flange (in a counterclockwise rotation) until the clutch loosens. The clutch then may be removed by hand.



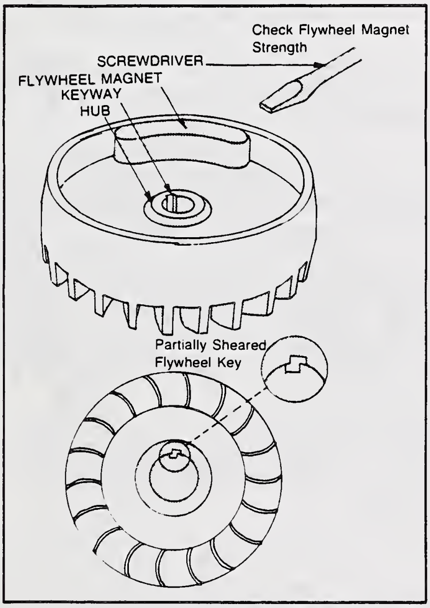


The next job is to remove the flywheel from the tapered shaft. Since the flywheel is wedged onto the tapered shaft, considerable force is required to break it loose. To protect the threads of the crankshaft, thread a nut flush with the end of the crankshaft. One person should grip the flywheel firmly as shown in the illustration. A second person place a hammer squarely on the nut. Then with a second hammer, strike the first hammer with a solid blow.



If this method of removing the flywheel fails, you will have to obtain a flywheel puller specifically designed for your engine model. Use it as instructed in your repair manual.

When the flywheel is loose, gently lift it from the crankshaft noting how the metal key fits into the slot of the crankshaft.



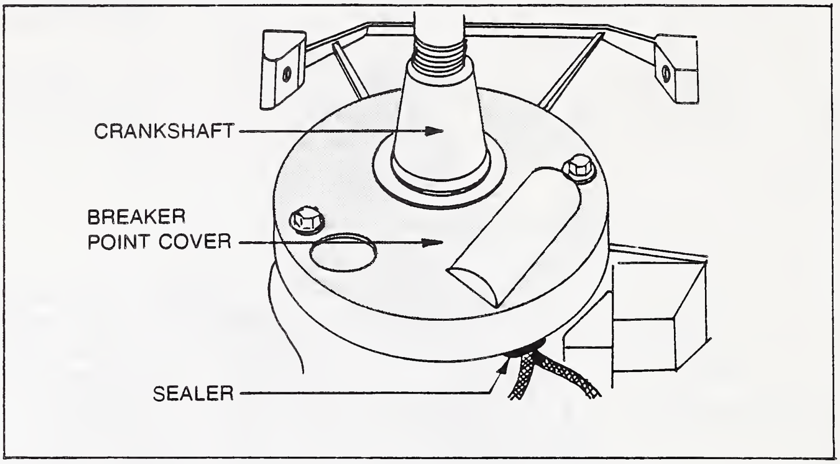
Do not drop the flywheel. Check for cracks inside the hub near the keyway and on the surface itself. If any cracks appear or if the keyway is worn, the flywheel should be replaced.

Check the flywheel magnet's strength by suspending an unmagnetized screwdriver approximately 2 cm from the magnet. The screwdriver should be strongly attracted to it. If the attraction is weak, the magnet or the entire flywheel may have to be replaced.

Lawn mower engines use an aluminum key to keep the flywheel secured. This soft key absorbs the wheel momentum if the lawn mower blade hits an unmoveable object. This prevents damage to the crankshaft. If the key is sheared or partially sheared engine timing will be affected. A partially sheared key should be replaced with a new key of the same type.

5. Service Breaker Point Assembly

(a) **Locate the breaker point assembly on your engine.** The breaker points on a lawn mower engine are located under a protective cover close to the crankshaft just under the flywheel. Wipe the dust from the cover with a clean rag to prevent dirt from getting into the breaker box.

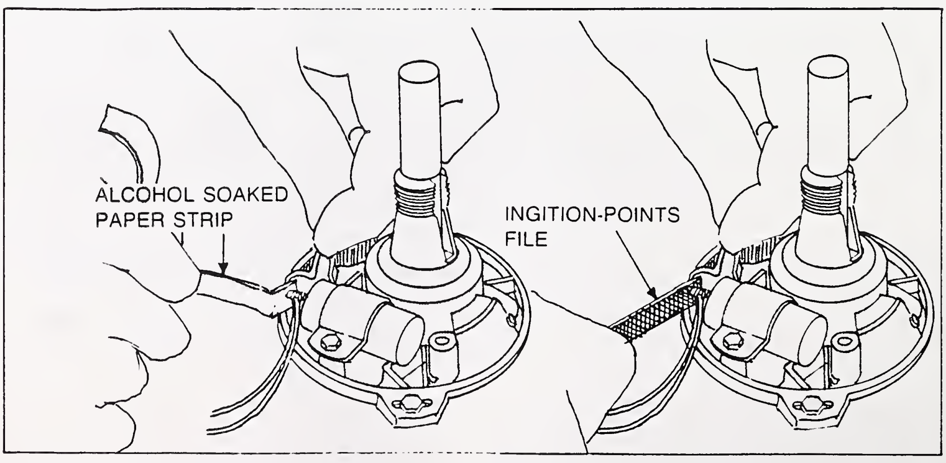


Note: Some engines have their breaker points located on the side of the crankcase and not under the flywheel.

(b) **Remove the protective cover.** Determine whether the points require restoring or replacing. New points and condenser are relatively inexpensive. Since it is somewhat difficult to get at the point assembly it is recommended that you replace the points and condenser once you have gained access to them.

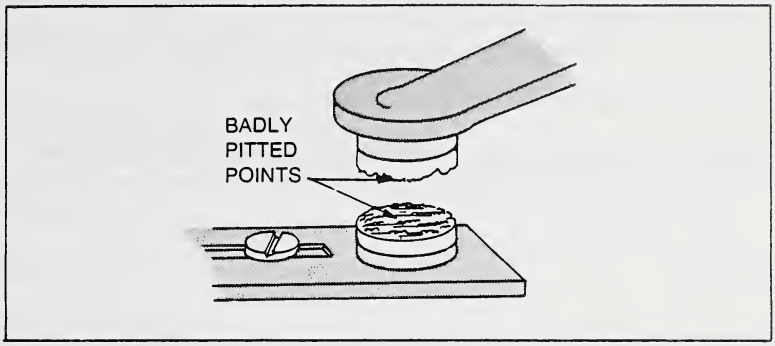
(i) **Restoring Breaker Points.** If the points show no signs of being burnt or pitted insert an ignition points file between them. File lightly to remove as little metal as possible making certain that the surfaces of the contacts are completely flat.

To remove any dust, filings or grease, soak a strip of paper in rubbing alcohol and pull it back and forth between the points. Remove the piece of paper by opening the points with your finger to prevent tearing the paper.

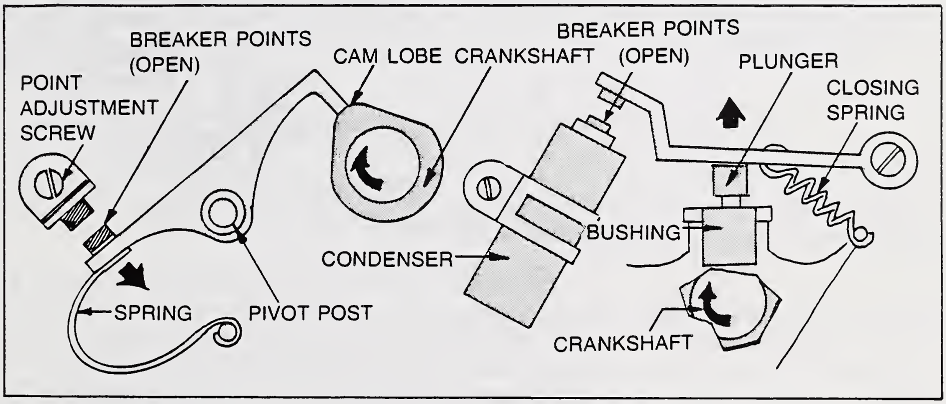


(ii) Replacing Breaker Points

If the point contacts are badly pitted, burned, or worn, replace them with a new set.



Ignitions are generally of two types, those activated by a removeable cam and those activated by a plunger. Engine manufacturers vary their styles in order to fit individual systems.

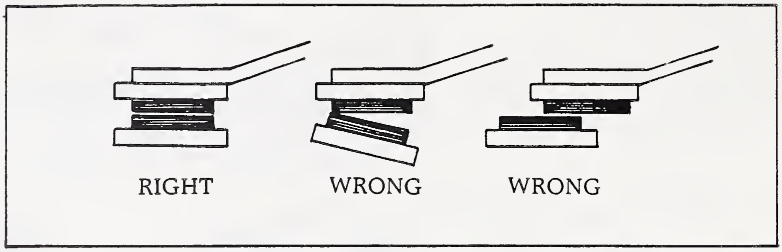


When replacing the breaker points and condenser follow the procedures outlined in the repair manual for your specific engine model.

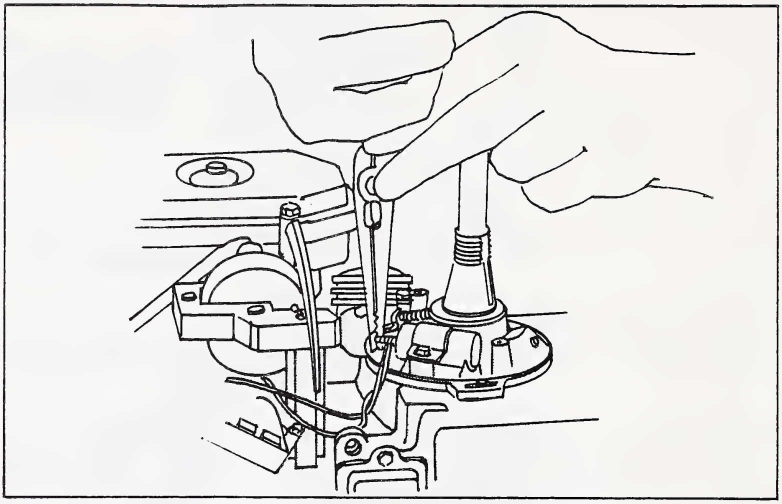
Check the cam lobe for wear. When reinstalling the points, be sure to install it right-side-up. If it is not installed correctly the points will open 180° ahead of time.

If the points use a plunger, check the plunger for wear and freedom of movement. Measure its length with a micrometer. The proper length is given in the repair manual.

After the new points are in place, turn the crankshaft until the points are completely closed. The points should make contact squarely.

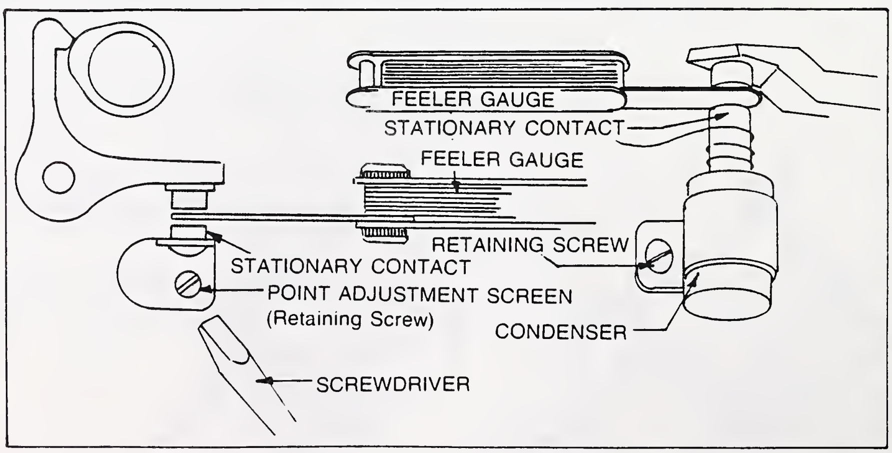


If an alignment problem exists, use long nose pliers to bend the arm that holds the moveable contact. Partial contact causes arcing and uneven wear.



(iii) Gapping the Points

Rotate the crankshaft until the points are fully open. Loosen the screw holding the stationary contact and insert the correct size (as per specifications) feeler gauge into the gap. Move the stationary contact until a light drag is felt as the feeler gauge is moved back and forth through the contact area. Carefully tighten the retaining screw without moving the points. Recheck the gap when you are finished. On most smaller engines with the armature mounted outside the flywheel, the only timing adjustment is the breaker points.



Carefully turn the crankshaft until the points are fully closed. Insert a piece of lintless paper and move the paper back and forth between the contacts. Open the breaker points with your fingers and withdraw the paper strip. This will avoid tearing the paper and allowing any pieces to remain between the points. New breaker points should be cleaned using this method to remove the protective oil film or any lint which may be on the contacts.

Note: Do not install the breaker point cover if timing is necessary.

Before installing the breaker point cover, apply a sealer (silicone sealant) to the point at which the primary wire passes under the breaker cover. Install the cover.

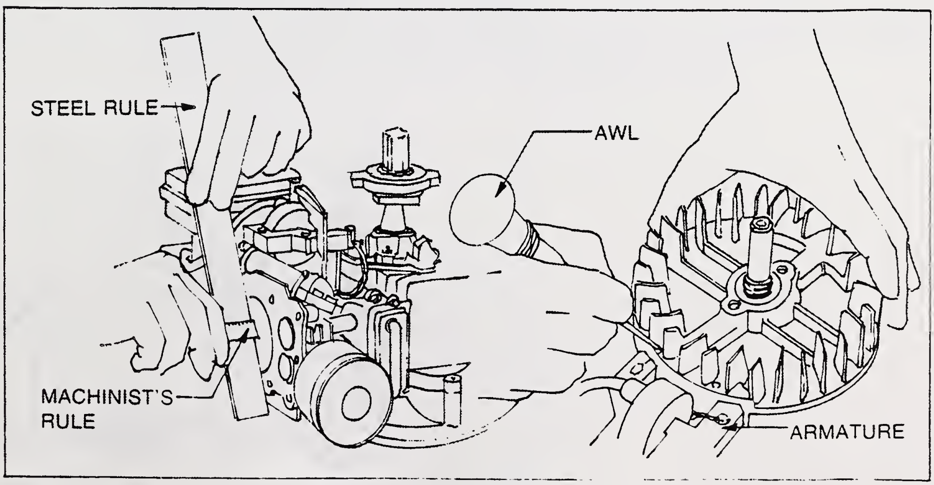
6. Ignition Timing

Small engines that have the armature mounted outside the flywheel do not require timing. The timing is adjusted by correctly gapping the breaker points. Engines with the armature-coil assembly mounted under the flywheel must have their ignition timing adjusted. Some engines have timing marks located on the armature and engine block. If this is the case, simply align the marks and tighten the armature. Other engines rely on finding the proper piston position and etching some marks. Timing accuracy depends on the correct breaker point setting, regardless which type of system is used.

(a) Etching Timing Marks (Requires removal of the cylinder head)

To locate the timing position, rotate the crankshaft until the piston is at TDC. Check the repair manual to find the piston for timing. (It will be given a measurement of BTDC.) Measure this distance by using two steel rules or similar measuring tools, as shown in the illustration below.

Without turning the crankshaft, insert the flywheel key and slide the flywheel back onto the crankshaft. Scribe a line at the edge of the flywheel adjacent to the armature. Scribe a second mark, directly opposite the first, on the armature.



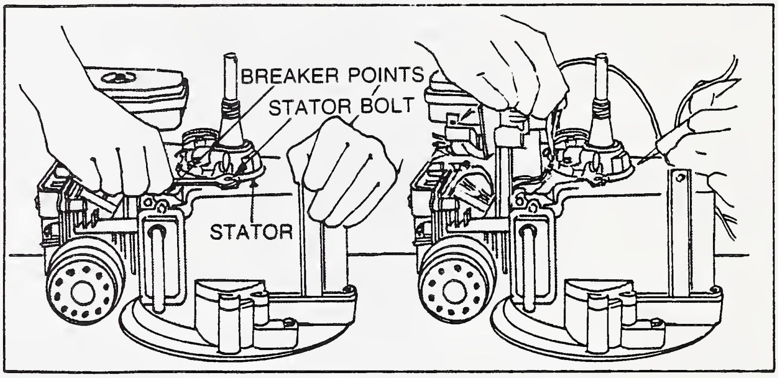
(b) **Setting the Timing**

There are two methods of adjusting timing, either by moving the stator or by moving the armature coil. The method used will depend upon the particular engine model.

(i) **Moving the Stator**

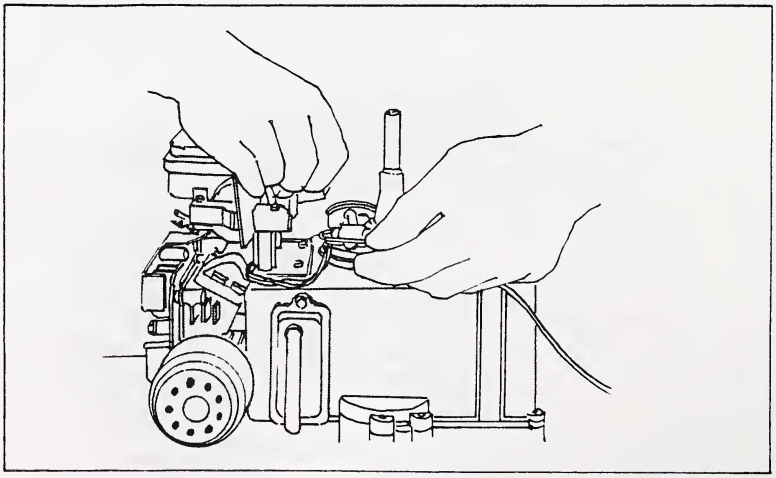
Align the timing marks. Without moving the crankshaft, gently remove the flywheel. Loosen the stator bolts.

Using a continuity tester, clip one lead to the moveable breaker arm. Touch the other lead to any bare metal surface on the engine. Turn the stator counterclockwise until the tester light flickers off. Carefully tighten the stator bolts, taking care not to move the stator.



(ii) **Moving the Armature Coil**

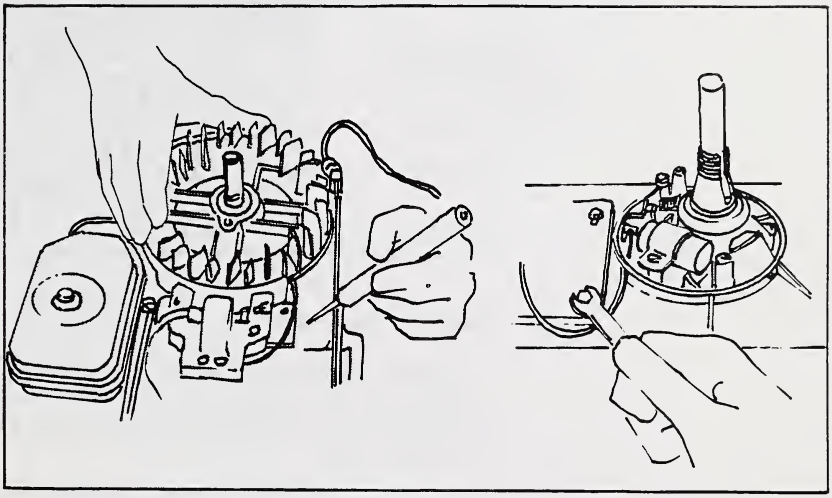
Attach one lead of the continuity tester to the moveable breaker arm or to the bare end of one of the wires connected to the breaker points. Fasten the test lead to allow installation of the flywheel. Position the flywheel key and slide the flywheel onto the crankshaft.



Touch the second lead of the tester to a bare metal surface on the engine. If the bulb fails to light, rotate the flywheel opposite its normal rotation until the light comes on. Slowly rotate the flywheel in the other direction until the light flickers out. Check the timing marks. If the marks are aligned then timing is correct. If not aligned, proceed with the next step.

Remove the flywheel (but do not turn the crankshaft) and disconnect the continuity tester. Loosen the bolts that hold armature mounting plate to the engine. Taking care not to turn the crankshaft, reinstall the key and flywheel. Move the armature until the timing marks are directly aligned. Remove the flywheel, and tighten the mounting plate bolts.

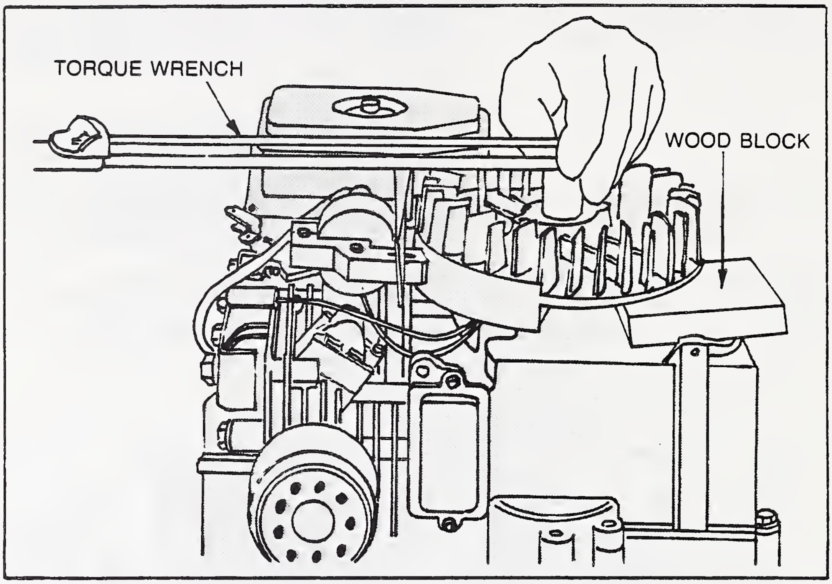
Install the breaker point cover as discussed earlier in this lesson.



7. Reinstall the Flywheel

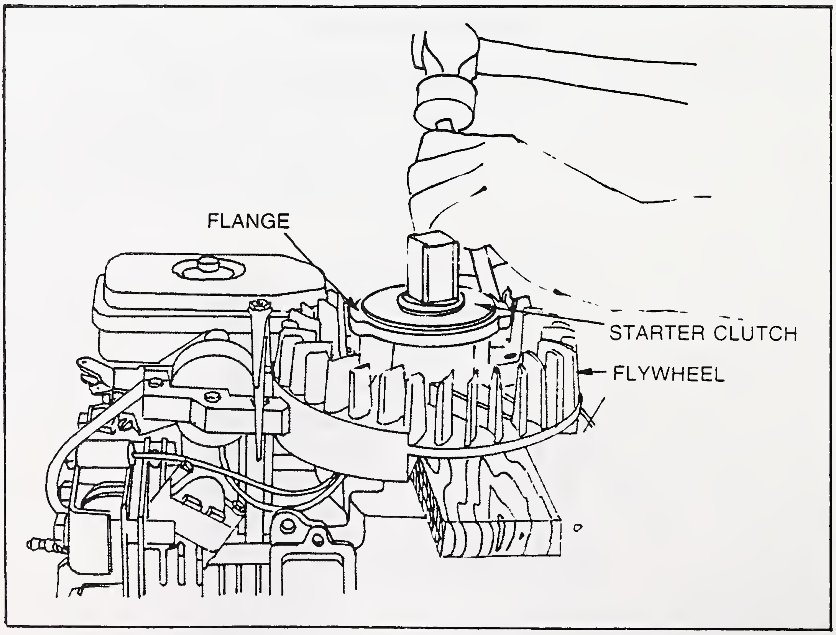
(a) Flywheel Retaining Nut Type

Reseat the flywheel and key. Install the retaining unit and wedge a wood block under the flywheel or use a flywheel holding tool to keep it from turning. Tighten the nut to the proper specifications using a torque wrench.



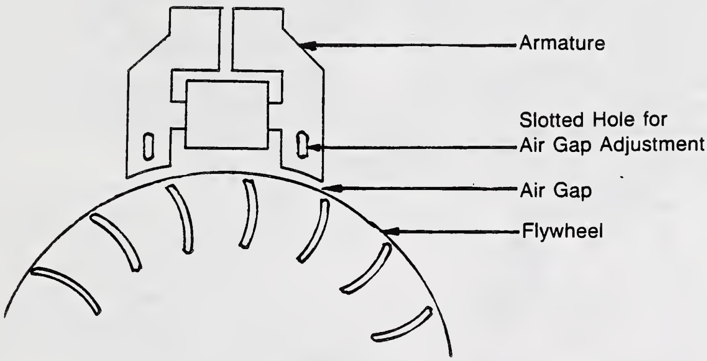
(b) **Starter Clutch Type**

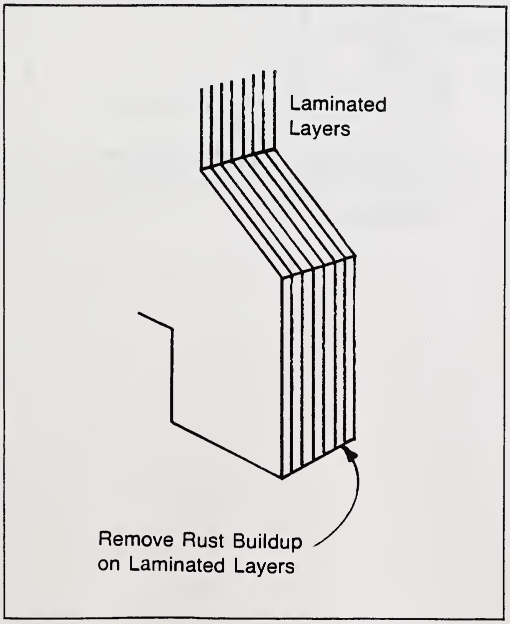
Reseat the flywheel and the key. Turn the clutch onto the threads of the crankshaft until it is finger tight. Wedge a wood block under the flywheel to keep it from turning. Give the clutch two firm taps with a hammer and wooden dowel as shown below.



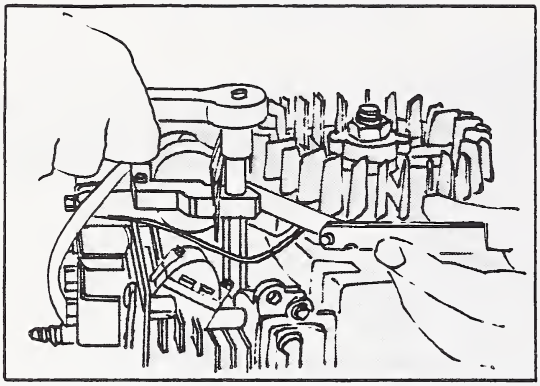
8. Adjust the Armature Air Gap

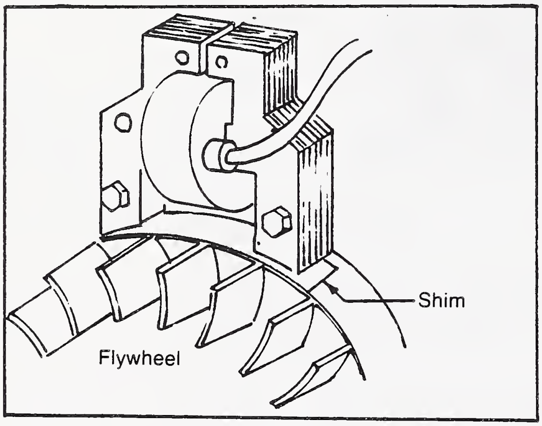
The air gap between the armature and the flywheel must be adjusted on an engine with an armature that is mounted outside the flywheel.





Remove the armature from the engine using the correct size wrench. **Do not use pliers.** Clean the cooling fins behind the armature. Then using a piece of emery paper clean any rust from the armature laminations. Coat the sanded areas with a light film of grease. Reinstall the armature.





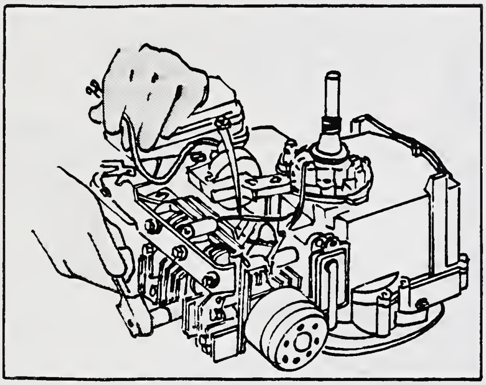
Turn the flywheel until one of the magnets is opposite the armature. Check the repair manual for the proper gap setting. Insert the proper size feeler gauge leaf between the magnet and one side of the armature. Loosen the mounting bolts and allow the magnet to pull the armature firmly against the gauge. Tighten the bolt that is closest to the gauge. Remove the gauge and slide it between the magnet and other end of armature. Tighten the second bolt. Withdraw the gauge.

The process above can be completed using a piece of shim stock of correct thickness. (A postcard can also be used.) Raise the armature and tighten one bolt. Place the shim between the armature and magnet. Loosen the bolt and allow the magnet to draw the armature against the shim. Tighten the bolts and remove the shim.

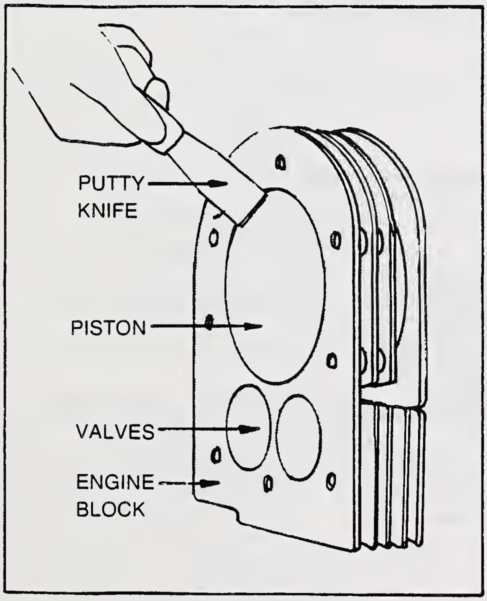
9. Check for Spark

Use test methods discussed under "Diagnostic Tests" to check for spark. If the spark test fails to produce a strong spark, the coil assembly may be at fault. (The coil assembly will have to be removed and taken to a small engine service center to have it thoroughly tested.)

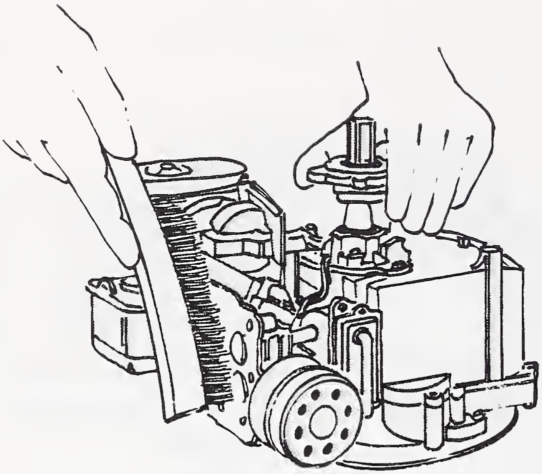
10. Remove the Cylinder Head



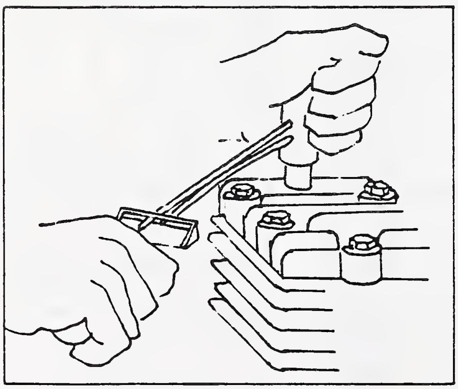
Use a socket wrench to remove the bolts that secure the head to the block. **Note:** Some engines have head bolts of different lengths. Note their correct location. To protect the cylinder head from warping, loosen bolts in pairs on opposite sides of the cylinder. Carefully remove the head and head gasket. Check the head gasket for signs of leakage or breaks. If the gasket shows signs of leaking, the problem may be a warped cylinder head.

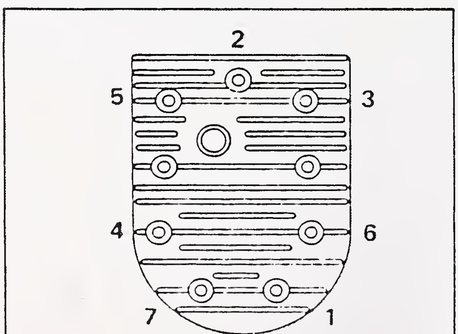


Turn the crankshaft until the valves are fully closed and the piston is at TDC. Carefully scrape all carbon from tops of the valves, piston head, and the inside of the cylinder head using a putty knife or carbon scraper. Be careful not to scratch the surface. **Do not scrape the surface of the block.**



Brush all surfaces, including the cylinder block with a stiff wire brush. These parts should gleam when you are finished.



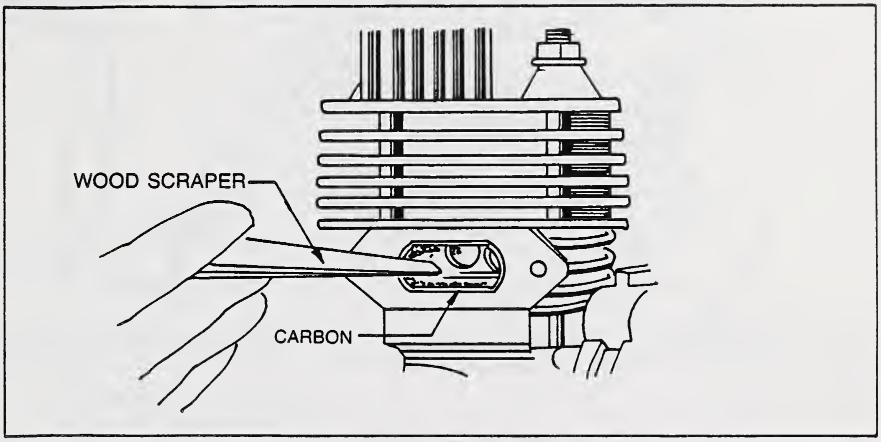


Fit a new head gasket between the cylinder head and engine block. Place all bolts in their proper locations and tighten them with your fingers. (If some of the head bolts secure the air shroud, reinstall the head at the same time you are installing the shroud.) Use a torque wrench to tighten the bolts to proper specifications. Follow the tightening sequence recommended by the engine manufacturer. (See example of tightening sequence shown at the left.)

11. Check Muffler for Restrictions

This procedure applies mainly to two stroke cycle engines. The muffler and exhaust ports tend to become clogged with carbon deposits

Remove the mounting screws and detach the muffler. Rotate the crankshaft until the piston moves down to cover the exhaust port. This will prevent any accumulations from falling into the cylinder. Scrape off any carbon using a **wooden stick.** Use compressed air to blow out the ports.



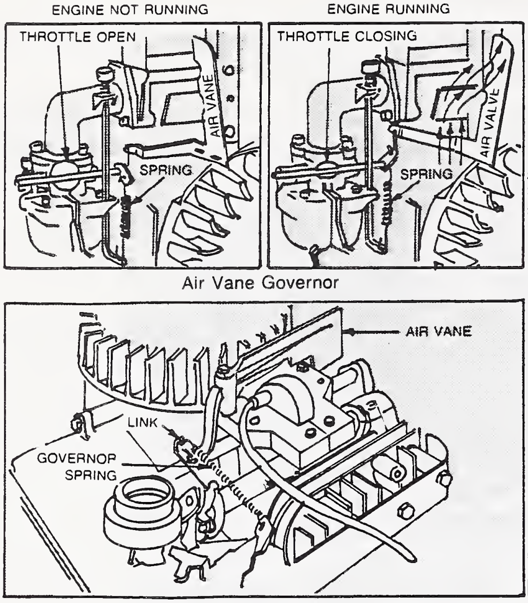
Clean the muffler in solvent. Then reinstall the muffler with a new gasket if the old one appears damaged.

12. Change Engine Oil (See Periodic Maintenance)

13. Service Air Filter (See Periodic Maintenance)

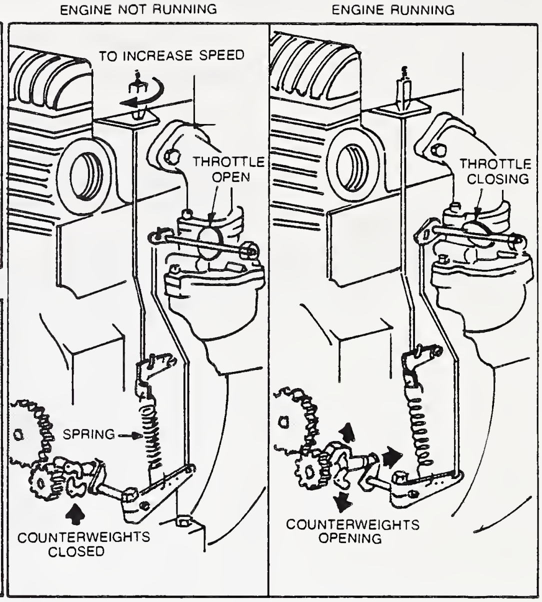
14. Check Governor Operation and Adjustment (See Engine Repair Manual)

To insure proper governor operation, replace any worn linkages or damaged springs. Inspect spring tension and free any sticking or binding parts.



Air Vane Governor

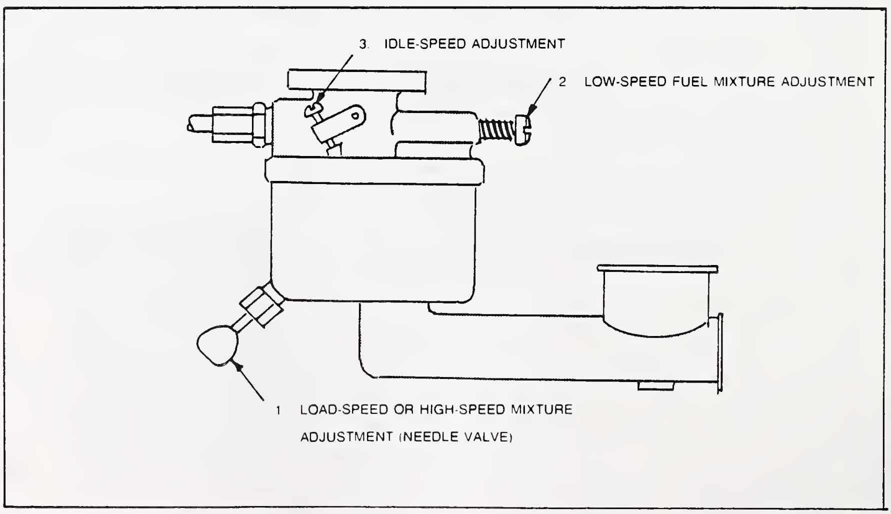
Air Vane Governor



Mechanical Governor

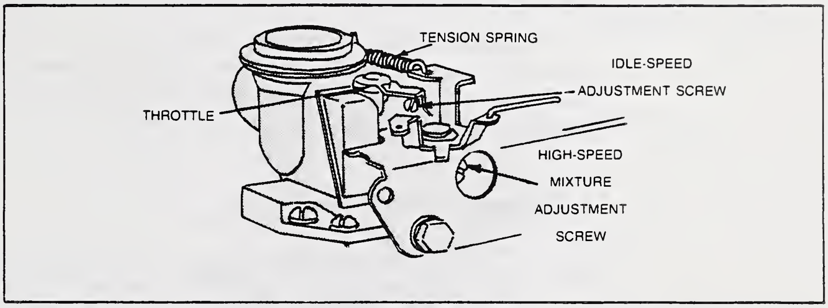
15. Adjust the Carburetor

Most carburetors allow three basic adjustments. The proper order of these adjustments are listed below. When turning the needle valve in, take care not to damage the seat as they are made of soft brass. Check to see that all linkages move freely before any adjustments are made. The location of the adjusting screws should be given in your repair manual.



(a) The High Speed Mixture Adjustment

In order for the engine to start, carefully turn the high-speed mixture screw (needle valve) clockwise until it just closes. **Avoid forcing it.** Back the screw out counterclockwise one and one half turns. Start the engine and allow it to warm up to normal operating temperature. If the engine runs roughly and emits black smoke, the fuel mixture is too rich. In this case the mixture screw should be turned clockwise.



When the engine is warmed up, open the throttle to normal operating speed (near wide open throttle). Turn the valve screw in clockwise until the engine begins to surge or run unevenly. From this point, turn the valve screw counterclockwise until maximum smoothness and top speed are reached. (For maximum power under heavy load, turn the valve screw counterclockwise up to one-eighth turn.)

(b) The Idle Mixture Adjustment

Note: Some engines may not have an idle-mixture adjustment.

The idle mixture adjustment should be made after the high-speed mixture has been set. Bring the engine near correct idle speed. Turn the idle mixture screw in clockwise until the engine begins to run roughly. Carefully turn the screw counterclockwise until the maximum idle speed and smoothest operation are obtained.

(c) The Idle-Speed Adjustment

The idle-speed adjustment screw prevents the throttle from closing completely. Turn this adjusting screw counterclockwise until the engine sounds as if it is about to stall. Then turn the screw clockwise approximately one half turn so that the engine runs evenly but does not race. Engines of less than ten horsepower should idle at approximately 1750 to 1800 min. The engine may overheat if idling too slowly.

Note: Most of the previous information describes methods of tune-up for a four stroke cycle engine. Tune-up of a two stroke cycle engine is somewhat different. Most of this information is applicable to two stroke cycle engines. With this and your engine repair manual you should not have too much difficulty adapting this information to your situation.

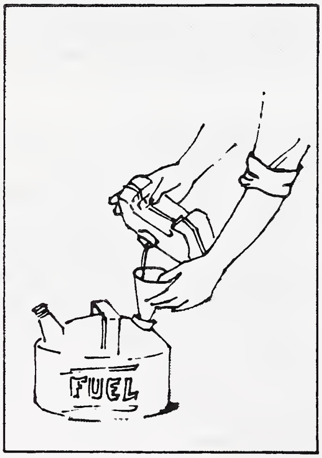
STORAGE

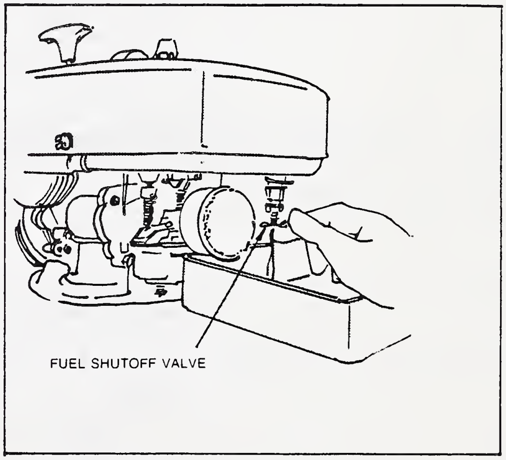
It is quite common for equipment that uses small engines of the two-cycle or four-cycle variety to be used only on a seasonal or periodic basis. For this reason proper preparation should be made to the equipment before storage and also it is imperative to introduce the machine back into service in a correct manner.

1. Drain the Fuel System

Fuel that is allowed to remain in the engine can cause serious problems. Gasoline evaporates leaving gummy deposits coating fuel parts.

Drain the fuel tank, carburetor, and lines. Clean the fuel filter screen. Run the engine until all the fuel is used up. Some carburetors have a drain valve.





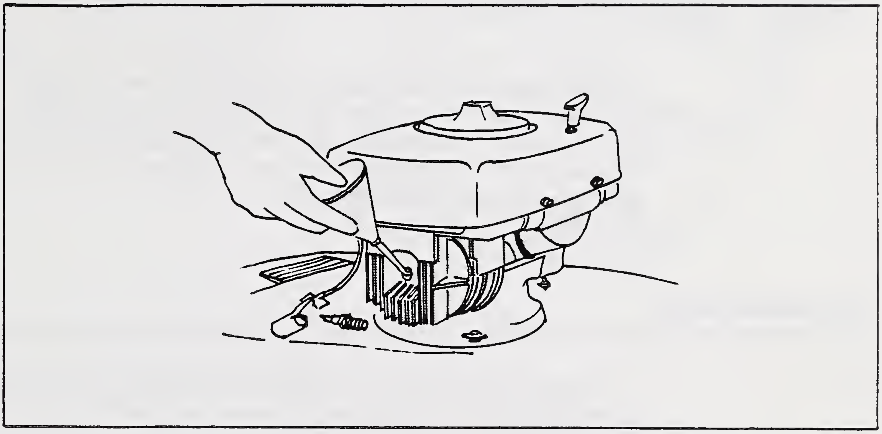
Note: If the engine is to be stored for less than thirty days, the fuel tank should be kept full. This will prevent condensation from occuring inside the fuel tank.

2. Change the Engine Oil

Change the oil while the engine is warm in order that most of the dirt and sediment in the crankcase will drain out with it.

3. Lubricate the Cylinder Wall

Remove the spark plug from the cylinder head. Squirt one ounce of motor oil into the cylinder. Use oil of the same weight as that is recommended for the crankcase (or for mixing with the fuel in the case of a two stroke cycle engine). Crank the engine over several times in order to distribute the oil evenly over the cylinder walls. This will prevent any rust and corrosion which may occur during storage. Reinstall the spark plug.



4. Clean the Engine

Clean the exterior of the engine. Remove all shrouds and guards in order to clean the complete surface of the engine. Remove all debris from between the fins or other areas of the equipment. Check that all linkages move freely and are not gummed up or in need of repair. If the engine uses a belt drive, loosen it so that it does not stretch from the constant pressure. If the engine uses a chain drive, then oil the chain lightly to prevent any rusting. Oil or otherwise lubricate all lubrication points as per the manufacturers recommendations.

5. Storing the Engine

Inspect exterior compononents for any part that may require repair. Store the unit in a clean, dry place, off the ground if possible. An air space is necessary under the machine so that moisture can not be absorbed. Cover the engine to keep it clean and secure the cover so that it can not be accidentally removed.

6. Returning the Engine to Service

(a) Check crankcase oil level.
(b) Service the air filter.
(c) Fill fuel tank with clean, fresh fuel.
(d) Check all bolts and screws for tightness.

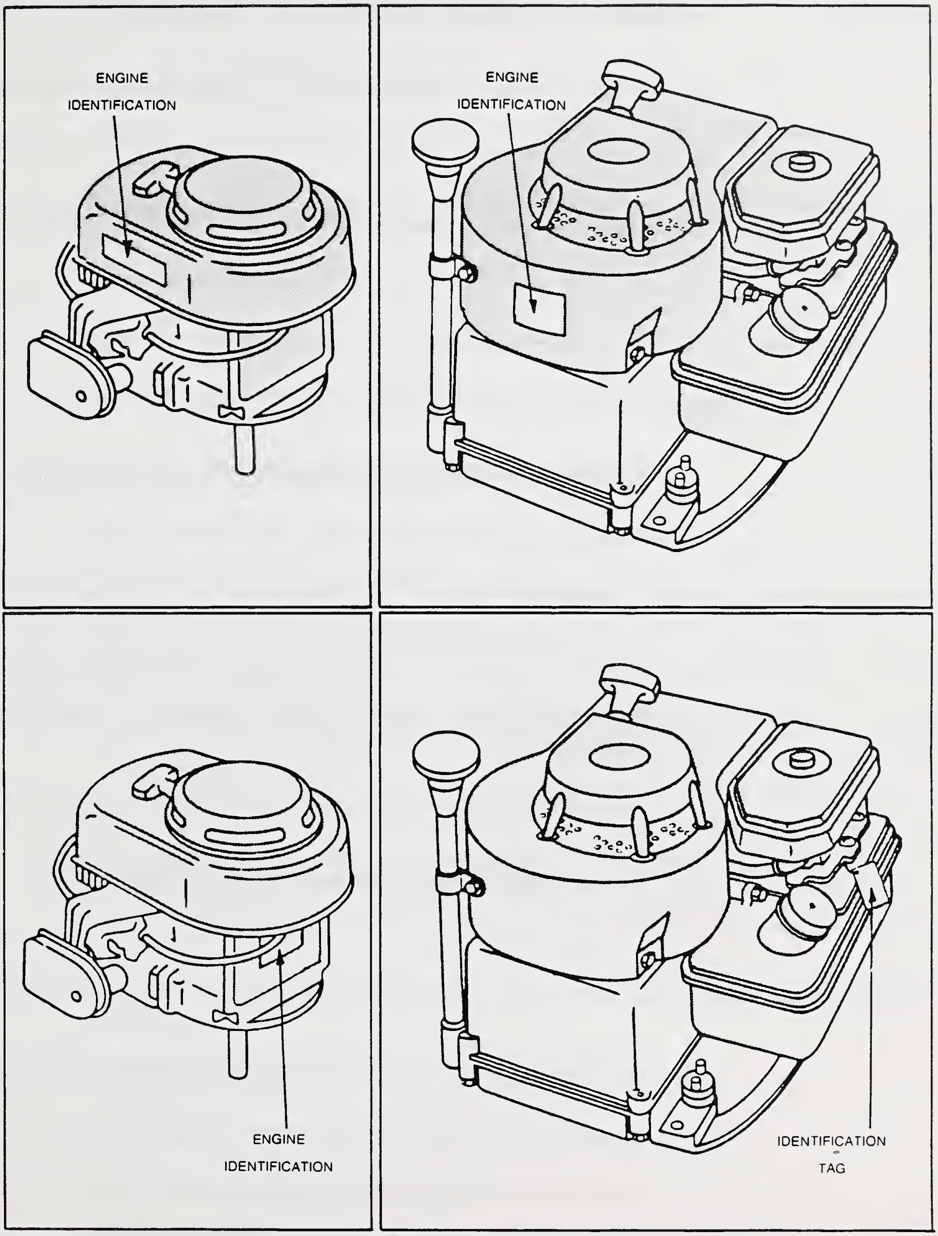
MANUALS AND SPECIFICATIONS

Before attempting any repair or service work on an engine, it is necessary that you have the proper repair manual for your specific make and model of engine. The manual outlines specifications for adjustments, specifies torque for different fasteners, and other information required. This book also will serve as a guide in performing the various steps necessary to do a complete and satisfactory job.

ORDERING PARTS

Proper identification of the engine is necessary for locating specifications in the repair manual as well as for purchasing replacement parts.

The engine usually has an identification plate located either on the engine block or on the flywheel shroud. Some engines do not have a plate, but the information is stamped directly onto the shroud. This identification plate usually includes the manufacturer, the serial number, the model number, and the engine type.



COSTING

It is always a good idea to calculate estimates for various servicing, tune-up, or repair jobs before starting the work. This will avoid any unexpected bills later. Estimates are also useful in deciding whether or not to make such repairs or replace the entire unit with a new one. A simple, self drawn cost sheet may be useful for this purpose.

EXERCISE 1 **Complete the following questions and send them in for correction.**

1. What is the most common problem to check when an engine will not start?

   ____

2. What three basic elements does an engine require in order to run?

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

3. What three possibilities could cause engine fuel flow problems?

   (a) ______________________________

   (b) ______________________________

   (c) ______________________________

4. Why is following a certain storage procedure a necessary part of small engine maintenance?

   ____

5. Why is moisture harmful to the internal parts of a small engine.

   ____

   ____

6. Why should oil be put in the cylinder of an engine before long term storage?

   ____

   ____

7. Why should fuel tanks be kept full during short term storage?

   ____

   ____

8. Why should fuel tanks be empty during long term storage?

____

____

9. What item is necessary before attempting any repair or service work on a small engine?

____

10. Other than fuel problems, what is the major cause of an engine overheating?

____

11. How would the problem in question 10 be remedied?

____

____

12. Why would a clogged fuel tank vent cause an engine to run unevenly?

____

____

13. Why would a low fuel supply cause an engine to run unevenly?

____

14. An engine will not start. It has been checked and shows signs of flooding. What should be done now?

____

____

____

____

15. A 2-cycle engine is missing when it runs. What should be checked first?

____

16. What could happen if a spark plug is installed too loosely?

____

____

17. What major factor governs the operating life of a small engine?

____

18. Most carburetors have ____________ basic adjustments. (Give the number)

19. Most small engines will start if the adjustment screws are opened approximately ____________ turns.

20. If an engine runs roughly and emits black smoke from the muffler, the fuel mixture is too ____________ and the needle valve should be turned ____________.

21. If the ignition system is functioning correctly, a blue spark should jump a ____________ mm gap.

22. How is the flywheel attached to the crankshaft?

____

____

____

23. Why are soft flywheel keys used on some small engines?

____

____

24. Why would an incorrect setting of the breaker points affect engine timing?

____

____

____

25. To order new breaker points what information would you require?

____

____

26. Do new breaker points require cleaning? Why or why not?

____

____

27. What type of feeler gauge is best for gapping spark plugs? Explain your answer.

____

____

____

28. What part of the small engine requires the most extensive and frequent service?

____

29. List the four steps recommended to be followed before storing a small 4-cycle gas engine.

(a) ____

(b) ____

(c) ____

(d) ____

EXERCISE 2 **Answer the following true or false questions.**

1. Low compression can be caused by a leaking head gasket. (True or False)

____

2. Carburetor adjustments should be made while the engine is cold. (True or False)

____

3. Blue smoke is a direct result of an incorrect fuel mixture. (True or False)

____

4. All new spark plugs are properly gapped by the manufacturer. (True or False)

____

5. To remove the flywheel, pry it off with a screwdriver. (True or False)

____

6. Rust reduces the efficiency of an ignition coil. (True or False)

____

7. A pair of small slip joint pliers should be used to remove the armature bolts. (True or False)

____

8. A continuity tester can be used for determining when the breaker points open. (True or False)

____

9. A carburetor which is incorrectly adjusted will cause the engine to surge. (True or False)

____

10. Stale gasoline causes hard starting. (True or False)

____

11. A dirty air cleaner could "choke" the engine. (True or False)

____

12. High engine temperatures could be caused by improper carburetor adjustments and incorrect engine timing. (True or False)

____

In the space below please give your comments (good or bad) with respect to this course and any suggestions for improvements that you may have. Indicate if you feel this course is missing anything and where you had trouble understanding any of the material.

Thank you for being with us. Please tell others about the course.

END OF LESSON 4